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GROUND TRUTH DATABASE FOR REGIONAL SEISMIC RESEARCH IN THE MIDDLE EAST AND NORTH AFRICA

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Final Report

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13. ABSTRACT *(Maximum 200 words)*
Our objective has been to collect, format, analyze and distribute waveforms, phase readings, and other information for regional events in the Middle East and North Africa (MENA). Sparse station coverage by the network of the prototype International Data Center (pIDC) has been augmented with data from other archives, primarily the IRIS Data Management Center. Our products include careful and consistent seismic data analysis; only two analysts have worked on this project, both previous Lead Analysts at the pIDC. To date, we have processed more than 900 events and identified over 8,100 regional phases. All information for one event is packaged in a regular file and can therefore be delivered via anonymous FTP. Unique identification numbers in the database tables allow any number of these events to be merged into one large dataset or loaded into an RDBMS. This report summarizes each of the completed datasets and gives an overview of how they were compiled. Additional documentation, available from the GTDB Web Site (URL: http://es1.multimax.com/~gtdb), includes maps, seismic bulletins, waveform and signal quality comments, analysis summaries, and sample waveform plots.

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Contents

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We appreciate the availability and ease of use of the continuous data archived at the IRIS Data Management Center. The IRIS program RDSEED was used to convert IRIS data to CSS3.0 format. We appreciate being granted autoDRM access to pIDC and USGS waveforms. The Datascope Seismic Analysis Package developed at IRIS's Joint Seismic Program Center was used in place of an RDBMS to manipulate CSS3.0 formatted table-files (Quinlan, 1995). Maps in this paper were made with Generic Mapping Tools (Wessel and Smith, 1995). Geotool was used for interactive analysis of the waveforms (Henson and Coyne, 1993). The Saudi dataset was analyzed by Flori Ryall under DOE Contract No. 1143.

Chapter 1

Overview

Introduction

Our objective has been to collect, format, analyze and distribute waveforms with phase readings and other information for regional events in the Middle East and North Africa (ME-NA). We include large events to serve as reference events but also include events near or below the current (global bulletin) threshold in the region. Sparse station coverage by the network of the prototype International Data Center (pIDC) has been augmented with data from other archives, primarily the IRIS Data Management Center. The result is a database rich in regional waveforms and phase arrivals that samples the diverse tectonics of ME-NA.

Our products include careful and consistent seismic data analysis: only two analysts have worked on this project, both of whom previously were Lead Analysts at the IDC. In our approach to analysis, events are grouped into geographic regions. Data redundancy helps to determine which observations are consistent with others in the region and which ones are spurious.

To date, we have processed about 1,000 events and identified about 10,500 regional phases. Events are organized into distinct datasets, each having unifying characteristics such as the source of the waveform data or the source of the hypocenter information. Data are stored in one consistent format and are made available by anonymous FTP. All information for one event is packaged in a regular file in Unix compressed tar format and can therefore be delivered via FTP without interaction with an on-line database. At the same time, unique identification numbers in the database tables allow any number of these events to be merged into one large dataset or loaded into a relational database management system (RDBMS).

Documentation for each dataset is provided on the Ground Truth Database (GTDB) Web Site. This site features location maps, seismic bulletins, waveform and signal quality comments, analysis summaries, sample waveform plots, and references to the source of the waveform data.

Our methods of delivering research-ready data products via FTP and providing detailed documentation over the Web have facilitated research involving the ME-NA region. In the past two years CTBT researchers have presented numerous papers which have utilized GTDB datasets. The primary users have been researchers at Lawrence Livermore National Labs (LLNL) and other scientists whose research was sponsored by DOE.

Report Organization

Chapter One presents information relative to the GTDB as a whole. This includes a description of how the datasets were compiled, how they were analyzed, how they are documented and how to obtain your own copy of the data. A one-paragraph summary of each completed dataset starts on page 19. Chapters 2-7 describe each of the completed datasets.

This report assumes familiarity with the database structure defined by the CSS3.0 Schema (Anderson *et. al*, 1990). A brief introduction to the CSS3.0 Schema starts on page 6 of this report. The "Documentation" section beginning on page 22 of this report is a tour of the GTDB Web Site, which is the source of the most up-to-date and complete documentation.

Construction of the GTDB Datasets

Method

1. Identify a list of events to be included in the GTDB;
2. Extract event-based waveform segments from all available archives, and convert foreign formats to CSS3.0;
3. Conduct interactive analysis of the waveforms: time and identify the phase arrivals, and add comments;
4. Correct all database table-files to conform to the CSS3.0 schema;
5. Make a seismic bulletin listing event location, phase arrivals, and remarks;
6. Put the completed dataset on the Multimax anonymous FTP site;
7. Put documentation for the dataset on the GTDB Web Site.

Step 3 was accomplished using Geotool (Henson and Coyne, 1993). Geotool works on flat files and reads and writes CSS3.0 format. Included in Step 3 is a summary of observations made during analysis. Steps 4 and 5 were accomplished using the Datascope Seismic Analysis Package (Quinlan, 1995). Datascope is a collection of programs which are useful for doing database procedures on flat files. These programs were combined in a series of scripts to process events after they have been analyzed. The main purpose of Step 5 was to make the identification numbers in the tables unique. This allows any number of the events to be merged into one larger dataset or to be loaded into an on-line database. During this step we also made several of the fields null, and we updated some of the fields.

Source of Hypocenters

We use different seismic bulletins for different datasets. These bulletins range from national bulletins (*e.g.*, the Spanish Dataset) to global bulletins such as the Reviewed Event Bulletin (REB) of the pIDC. Where possible, we reference regional bulletins to the USGS Monthly or the USGS Earthquake Data Reports (EDR).

Source of Waveforms

Several key stations in the Middle East which are planned for the pIDC network are not yet on-line (e.g. THR in Iran, LXAR in Egypt, GEYT in Turkmenistan, FURI in Ethiopia, BRTR in Turkey). Other stations which are listed in the pIDC network do not regularly contribute data to the archives. These factors have caused regional waveforms to be sparse in ME-NA relative to other regions. Availability of the IRIS database[1], including historical archives, was a major factor in overcoming the lack of regional ME-NA data available through the pIDC.

The program ReqData (Henson and Grant, 1996) was developed to handle requests for waveform data from Internet sites running an autoDRM (Automatic Data Request Manager; Kradolfer, 1993). Both the pIDC and the USGS use autoDRM for exchange of seismic waveforms. ReqData is a set of programs that can be used to submit GSE2.0 formatted waveform requests and automatically parse the email responses. Given an event time and location, travel times are used to compute request-time-windows for a list of stations. Waveform data received in GSE2.0 format are converted to CSS3.0 format and stored in a user-defined directory. The status of multiple requests can be monitored through the system's log files.

A modified ReqData was used to format Breq_Fast requests to IRIS, but the results were not automatically parsed. Additional data came from archives available over the Internet or through personal contacts.

Waveform data from over 270 different sites, including arrays and dense networks (*e.g.*, KNET, ISN, ILPA), are available through the GTDB. The subset of stations located in the ME-NA region is shown in Figure 1. Most of the stations shown in this figure provided *regional* waveforms to the database. Stations and their affiliations are listed in Table 1.

The pIDC stores continuous data for Primary stations and event-segments for Auxiliary stations (PRI and AUX in column 1 of Table 1). In general, the IRIS DMC stores continuous data for the time periods shown in the next-to-last column in Table 1. Stations with a "Y" in the USGS column have segmented data available from the USGS autoDRM for the listed station. Some of the stations may not be available through any open archives (*e.g.*, IRIS DMC, Geoscope, Mednet) although they are still in operation (*e.g.*, MAIO).

For some of the pIDC stations, we had better results retrieving data from the IRIS archives than from the pIDC archives for two reasons. Some Auxiliary stations in the pIDC network contribute data very infrequently to the pIDC bulletin (*e.g.*, KMBO). Also, since IRIS stores continuous data, we can often obtain a more complete waveform from IRIS for a given pIDC Auxiliary station (*e.g.*, NIL). However, there is a time delay (often months) for the IRIS DMC to archive the data from some stations, whereas the pIDC data are available within hours after the event.

[1]The Incorporated Research Institutions for Seismology's Data Management Center (IRIS DMC) is in Seattle, Washington.

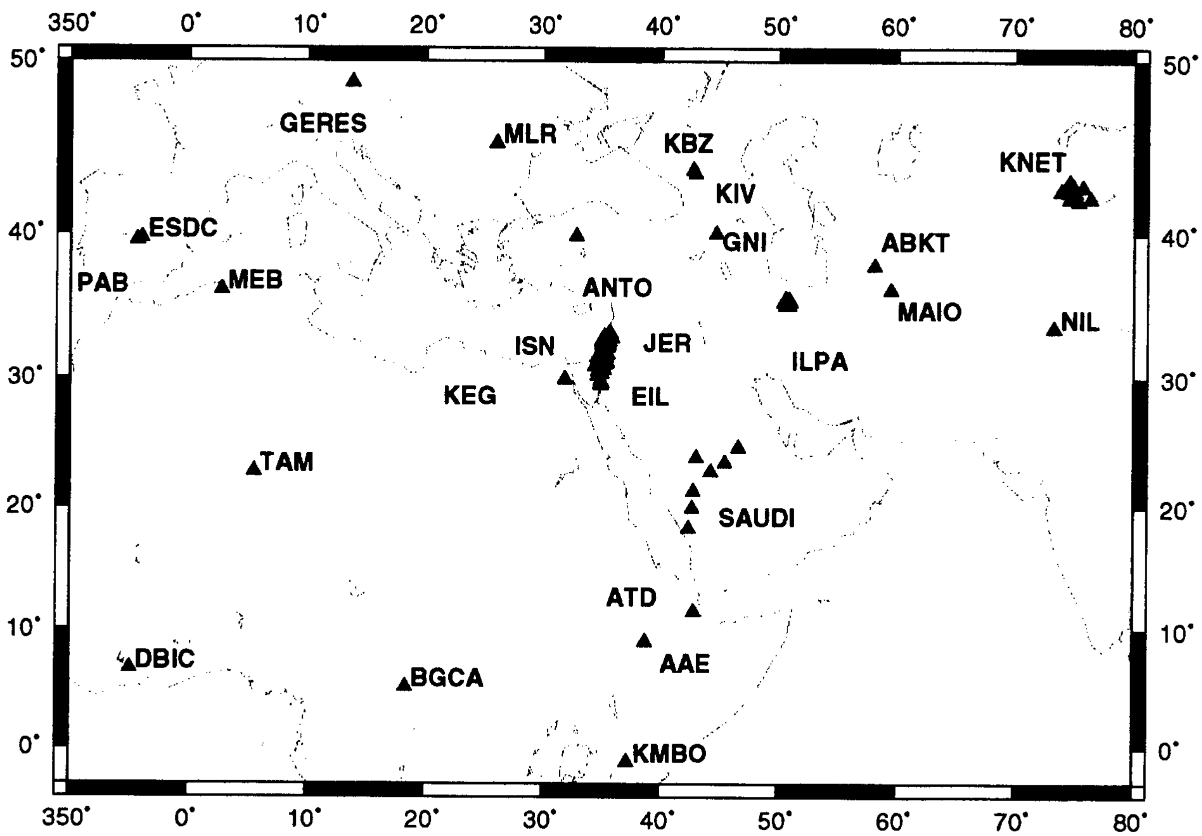


Figure 1: Stations which have contributed regional waveforms to the GTDB. Station affiliations are listed in Table 1.

Table 1. Partial Listing of Stations and Affiliations

IDC	Sta Code	Lat	Lon	Station Name	IRIS Affiliation		USGS
AUX	AAE	9.0	38.8	Addis Ababa, Ethiopia	iris/usgs(gsn)	(94-)	Y
	AAK	42.6	74.5	Ala-Archa, Kyrgyzstan	iris/ida(gsn)	(90-)	
PRI	ABKT	37.9	58.1	Alibek, Turkmenistan	irs/ida(gsn)	(93-)	Y
AUX	ANTO	39.9	32.8	Ankara, Turkey	iris/usgs(gsn)		Y
AUX	ATD	11.5	42.8	Arta Tunnel, Djibouti	geoscope	(93-)	
PRI	BGCA	5.2	18.4	Bogoin, Cent.African Rep.			Y
	BGIO	31.7	35.1	Bar Giyyora, Israel	usgs	(86-88)	Y
PRI	DBIC	6.7	-4.8	Dimbroko, Ivory Coast			Y
AUX	EIL	29.6	36.0	Eilat, Israel	usgs-gdsn	(72-79)	
PRI	ESDC	39.7	-4.0	Sonseca Array, Spain			
PRI	GERES	48.5	15.0	GERESS Array, Germany			
AUX	GNI	40.0	44.7	Garni, Armenia	iris/usgs(gsn)	(91-)	
	ILPA	35.7	50.6	Iranian LP Array	ARPA	(78-79)	
	ISN	31.7	30.2	Israel Seis. Net, incl. BGIO			
AUX	JER	31.8	35.2	Jerusalem, Israel			
PRI	KBZ	42.0	39.5	Khabaz, Russia			
AUX	KEG	29.9	31.8	Kottamya, Egypt	mednet	(90-)	
	KIV	44.0	42.7	Kislovodsk, Russia	iris/ida(gsn)	(88-)	Y
PRI	KMBO	-1.1	37.2	Kilima Mbogo, Kenya	iris/usgs(gsn)/geofon	(95-)	Y
	KNET	42.6	74.5	Kyrgyzstan Net., incl AAK	iris/ucsd		
	MAIO	36.3	59.5	Mashhad, Iran	usgs/gdsn	(75-78)	
	MEB	36.3	2.7	Medea, Algeria	mednet	(92-94)	
AUX	MLR	45.5	25.9	Muntele Rosu, Romania			
AUX	NIL	33.6	73.2	Nilore, Pakistan	iris/ida(gsn)	(94-)	
AUX	PAB	39.5	-4.3	San Pablo, Spain	iris/usgs(gsn)	(92-)	Y
	RAYN	23.6	45.6	Ar Rayn, Saudi Arabia	iris/ida(gsn)	(97-)	
	SAUDI	23.6	45.6	temporary, incl. RAYN	iris/ucsd	(96-97)	
	TAM	22.8	5.5	Tamanrasset, Algeria	geoscope	(83-)	

Center for Seismic Studies Version 3 Database Schema

This section describes the subset of the Center for Seismic Studies Version 3 Database Schema[2] used to build the GTDB. The schema (table definitions) comprise a series of relations (tables) which are in turn defined by attributes (fields).[3] Tables are linked to each other through one or more table keys. The CSS3.0 Schema is defined in the Schema Reference Manual (Anderson *et al.*, 1990). The distribution of the Datascope Seismic Analysis Package includes a program, **dbhelp**, which is very useful for viewing and learning the CSS3.0 Schema. The electronic version of the CSS3.0 Schema distributed with Datascope has been installed at the GTDB Web Site[4].

In previous work with ground-truth databases (Grant and Coyne, 1992; Grant *et al.*, 1993), new tables were created to accomodate information. In the current project, we rely on existing CSS3.0 tables.[5] Information that does not have a place in the defined schema is stored in the *remark* table or as part of the (non-table) documentation distributed from the GTDB Web Site. A few of the fields have been used differently from the CSS3.0 Schema definitions. These differences are outlined below.

Of the 21 core tables defined in the CSS3.0 Schema, the GTDB utilizes the nine tables shown in Figure 2. In that figure, tables are represented by white rectangles, and table keys are shown in shaded areas. Each row of the *wfdisc* table includes the information necessary to describe one waveform (*e.g.*, the directory and filename of the waveform). The waveform file itself is stored as a binary data file on disc.[6] The *origin* table describes the event (*e.g.*, origin time, latitude, longitude, mb). These two tables are linked by the *wftag* table.

The *assoc*, *arrival* and *remark* tables are created by the analyst.[7] Each row in the *arrival* table describes one seismic phase arrival. The *assoc* table associates arrivals to origins. There can be zero or many rows of remarks for each origin. In the GTDB, the same number, evid, links *remark* to *origin*, *assoc* to *origin*, and *wftag* to *origin*.[8] The name of the event directory is also based on evid (*e.g.*, ev*evid*.tar.Z). The *site*, *sitechan*, and *affiliation* tables describe the location of and equipment at each site.

For the ILPA/MAIO dataset, we used a Datascope extension to CSS3.0 called the *wfedit* table. Each row of the *wfedit* table specifies a "time slice for which a specified waveform has a problem, identified by the probtype field". Our implementation of this table is described in the documentation of the ILPA/MAIO dataset on the GTDB Web Site[9] and in the ILPA/MAIO Handbook (Grant *et al.* 1996b, page 18).

---

[2] referred to in this report as the CSS3.0 Schema.

[3] For example, *origin*.arid refers to the arid field of the *origin* table.

[4] URL: http://es1.multimax.com/~gtdb/TEXT/css30.html

[5] The exception is the *wfedit* table, defined by the authors of Datascope

[6] This is true of both on-line relational databases and databases consisting of flat-files.

[7] In automatic processing systems, such as that running at the prototype-IDC, the *assoc* and *arrival* tables are created by automatic arrival pickers and association programs. Each GTDB phase was interactively added using Geotool. Therefore, some of the fields in *assoc* and *arrival* hold default values that would otherwise be filled in by the processing programs.

[8] This is a GTDB simplification. According to CSS3.0 Schema definitions, orid links *origin* and *assoc*, and commid links *origin* and *remark* as shown in Figure 2. These are usually different numbers but we have set them all equal.

[9] URL: http://es1.multimax.com/~gtdb/ilpa/WFQC/reg3wfqc.html

In constructing the table-files for the GTDB, we found it useful to make slight departures from the CSS3.0 Schema for a few fields. Explanations of these differences listed below.

origin.dtype

This field is the depth determination flag. The CSS3.0 Schema calls for four permitted values: f, d, r, or g. However, when the *origin* information was from USGS bulletins, we left the dtype field unchanged. The field is defined below:

for author = REB:

```
f  free;
d  from depth phases;
r  restrained by location program;
g  restrained by geophysicist.
```

for author = USGS[10]

```
A  assigned;
D  restricted based on 2 or more pP phases;
N  restrained to normal depth (33 km);
G  restrained by geophysicist;
%  questionable value;
?  poor depth estimate;
_  good depth estimate (estimated error less than 8.5 km
                       based on 90% confidence ellipse)
```

origin.ndef and *origin*.nass

We followed the Datascope modifications for catalogs where arrivals are not available.[11] For the number of defining phases, ndef, we use the number of phases used to locate the event in the original catalog. For the number of associated phases, nass, we use the number of arrivals in the current database that are associated with this event.

arrival.qual

This field is used to denote the sharpness of the onset of a seismic phase. The CSS3.0 Schema relates it to timing accuracy as follows:

```
i (impulsive, accurate to within 0.2 s);
e (emergent, accuracy between 0.2 to 1.0 s);
w (weak, timing uncertain to > 1 s).
```

In the GTDB application, the quality grades have been redefined as explained on page 14. In most of the datasets, the signal quality comments are listed in the *remark* table. For a few regions of the Saudi Dataset, the quality designations have been inserted in the *arrival* table using Geotool. The quality definitions, which may change slightly from region to region, are listed with the "Analysis Notes" on the Web page describing each region.

[10]Definitions are from the HDF file at URL:ftp://widow.iris.washington.edu/HTM/hypos.htm

[11]Arrival information is often available from the original sources of the catalogs but has not been included in the GTDB. Only phase arrivals interactively picked by Flori Ryall or Bob Wagner are included.

origin.etype

This field is used to identify the type of seismic event when known. The CSS3.0 Schema calls for qb (quarry blast); eq (earthquake); me (marine explosion); ex (other explosion); o (other source of known type); l (local event); r (regional event); t (teleseismic event). In practice, only the latter three definitions are used.

GTDB modifications (Grant *et al.*, 1993) use the following range for etype: eq (earthquake); qb (quarry blast); qmt (quarry or mine tremor, including rock bursts); nu (nuclear explosion); nc (nuclear collapse); u (unknown).

Notes About Identification Numbers in the GTDB

- Several of the table keys in the CSS3.0 Schema are numbers: orid (origin ID); evid (event ID); wfid (waveform ID); arid (arrival ID); and commid (comment ID). In building the GTDB, we have made sure that all the numerical table keys are unique across the whole database: all arids are unique, all orids are unique, all wfids are unique, etc. This measure is what allows any number of the GTDB events to be loaded into one RDBMS account.
- Although the ID numbers are unique, they are not always consecutive; gaps exist. The user should not assume that something is missing if an ID number was skipped. For example, the first event in the Puertollano region of the Spanish Dataset is evid 103. The second event is evid 106. The events in between are not a part of the GTDB.
- Some of the ID numbers in the GTDB were simplified as follows: evid=orid=*origin*.commid.

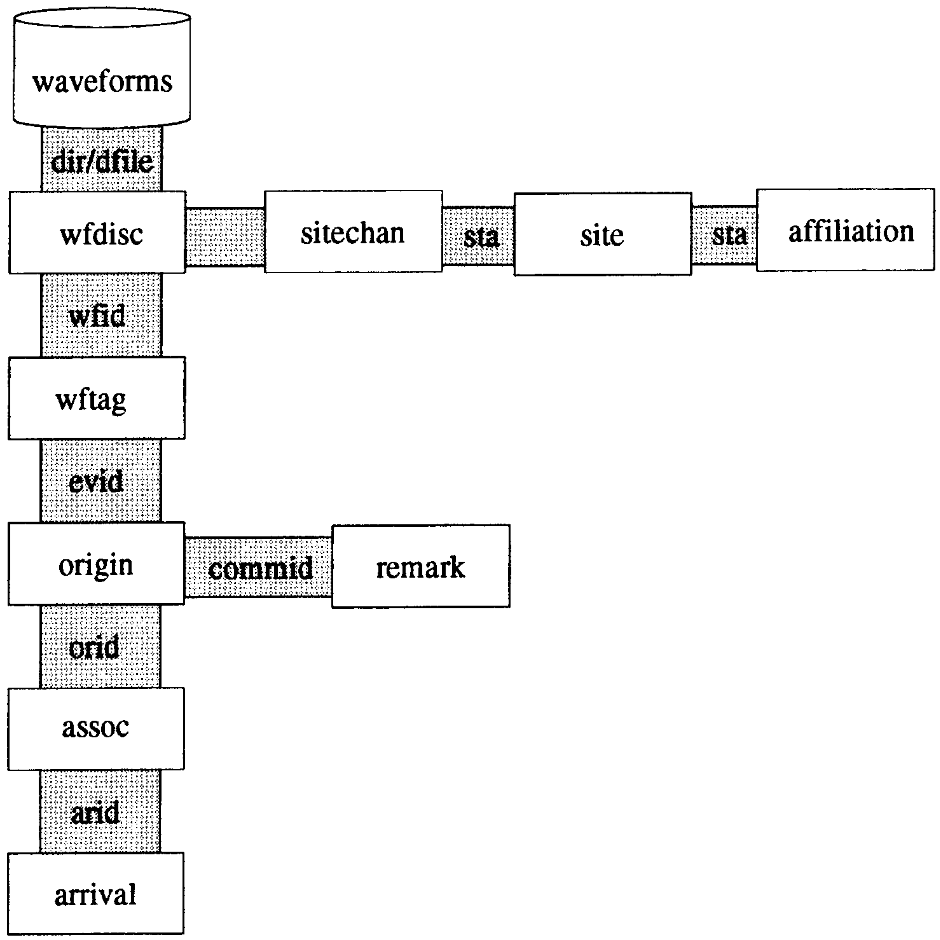


Figure 2: The subset of the core tables from the CSS3.0 Schema used to build the GTDB. Tables are represented by white rectangles; table keys are shown in shaded areas. Each row of the *wfdisc* table describes one waveform (*e.g.* the directory and filename (dfile) points to the waveform stored on disc). Each row of the *origin* table represents one event . These two tables are linked by the *wftag* table. The *assoc*, *arrival* and *remark* tables are created by the analyst. Each row in the *arrival* table describes one seismic phase arrival. There is a corresponding row in the *assoc* table which associates the arrival to the event which generated it. There can be zero or many rows of remarks for each row of the *origin*. In the GTDB, evid=orid=*origin*.commid. The *site*, *sitechan* and *affiliation* tables describe the stations, channels and networks. Several table keys are necessary to link *sitechan* and *wfdisc* including sta, chan, and time.

Event Directories

The directory structure of the GTDB is based on having all waveforms and CSS3.0 table-files[12] relating to one event be located in a single directory. These directories are organized by dataset and by the geographic region within the dataset. As an example, the file ev513.tar.Z unpacks into the event-directory, named ev513, with the following contents:

```
Comments       ev513.arrival   ev513.site      wf
ev513.origin   ev513.assoc     ev513.sitechan
ev513.remark   ev513.wfdisc    ev513.wftag
```

These are all the files for event 513 of the Zagros region of the Saudi Dataset[13]. Waveforms are under the **wf** directory. For this event, there are 17 waveform files.

```
ABKT.BHE.821442023.36.w  HALM.BHN.821442038.47.w  RAYN.BHN.821442054.11.w
ABKT.BHN.821442023.46.w  HALM.BHZ.821442063.14.w  RAYN.BHZ.821442052.01.w
ABKT.BHZ.821442023.46.w  RANI.BHE.821442141.73.w  SODA.BHE.821442179.83.w
ANTO.BHN.821442280.00.w  RANI.BHN.821442123.66.w  SODA.BHN.821442122.43.w
ANTO.BHZ.821442134.40.w  RANI.BHZ.821442151.88.w  SODA.BHZ.821442125.13.w
HALM.BHE.821442055.84.w  RAYN.BHE.821442130.98.w
```

The waveform files are named for the station, channel, and start time of the waveform.[14] The above-listed waveforms were obtained from the IRIS DMC. Waveforms obtained from the pIDC will have channel names in small-case letters.

Event directories are available as Unix compressed tar files at an anonymous FTP site. The event directory described above is available at

`ftp:es2.multimax.com/pub/gtdb/saudi/zagros/ev513.tar.Z`

One advantage of this structure is that all the information for one event is packaged as a regular file and can therefore be delivered via anonymous FTP without interaction with an on-line database. At the same time, unique identification numbers in the tables allow any number of these events to be merged into one large dataset or loaded into a RDBMS (relational database management system).

The GTDB table-files are not in an on-line database which can be queried. However, the information provided on the GTDB Web Site should be enough to help the user decide which GTDB datasets meet the criteria required for a given research project.

[12]The term "table-file" indicates a flat file which is formatted according to specific database table definitions— in this case, CSS3.0 format. These table-files are ready to be loaded directly into an on-line database. In this report, they are referred to simply as tables.

[13]A description of the Saudi Dataset begins on page 103 of this report.

[14]In the CSS3.0 Schema, times are often given as "epochal" time, which is the number of seconds since hour 0 January 1, 1970.

Interactive Waveform Analysis

The GTDB is populated with 934 events and 10,496 associated phases. Of these, 8,378 are regional phases (event-station distance less than 20 degrees). Table 2 summarizes the associated phases and key regional stations for each dataset.

Over 1,000 events have been interactively analyzed by Flori Ryall or Bob Wagner for this project.[15] The resulting phase information is stored in the *assoc* and *arrival* table-files. Amplitudes and periods of the phases were not measured. Other than bandpass filtering, no data processing was performed on the arrivals.

The purpose in performing this seismic waveform analysis is three-fold. First, it provides reference time points on the waveforms for users who have routines that depend on arrival times. Second, it gives us a chance to review the data for quality control and to verify the time windows. More importantly, it provides a reference dataset of events at regional distances in the ME-NA region for which the phases have been carefully and consistently timed and identified. Many examples of the observations are included in Chapters 2-7 in the sections showing sample plots.

Our approach to analysis is to look at events grouped by geographic region within each dataset rather than chronologically. We refer to these groups of events as clusters. Some clusters are comprised of events which are closely located and very similar (*e.g.* repeated blasts from a single quarry or earthquake aftershock series). Other clusters have a wider geographical extent. One advantage of this approach is that an understanding of one event can often be applied to nearby events. This is useful when there are large magnitude and small magnitude events in one cluster.

In addition to the *assoc* and *arrival* table-files, the analyst also creates notes for each region and comments about specific events. The comments are stored in the *remark* table-file. The analysis notes, written after completion of each region or cluster of events, are featured on the GTDB Web Site. They are written by the analyst in order to alert the GTDB user to interesting or unusual observations. They also list specific guidelines followed during analysis of the region which may be critical for interpreting the *assoc* and *arrival* tables.

The essence of this database is the consistency with which the analysis was performed *within each cluster of events.* Each dataset was analyzed by a single analyst. Within a given cluster, phases were named and timed in the same way from event to event. Each cluster was carefully reviewed to check for inconsistencies. GTDB users can be confident that when real phases were observed in the data with unambiguous onset times, they were added to the database. Phases with unclear onsets, however, were only noted in the *remark* table and not added to the database.

Even within clusters of similar events, data quality and availability varies because of variations in event magnitude. Phases were picked as well as possible depending on the quality of the available data.

Events observed at distances between 15 and 25 degrees can have very complex P codas. Individual phases are difficult to identify near the Pn/P crossover point. Both of these phases as well as the triplication P's, can be observed. For large events one might see several distinct

[15] For the statistics in Table 2, only events with associated phases are counted.

P phases, whereas for the smaller events, a later P might be the first arrival observed.

Near the Pn/P crossover distance, it is difficult to distinguish whether the first arrival is Pn or P. Analysis of the Saudi Dataset employed a strict guideline for identifying the first P arrival: P arrivals observed beyond 16 degrees were not identified as Pn. The nominal distance of 16 degrees was also used as a guideline for the REB-EQ Dataset. However, some P-type phases observed beyond 16 degrees are labelled Pn because of their observed characteristics. Further research into the crustal models for the ME-NA region may lead to more precise phase identifications for phases observed near the Pn/P crossover distance.

Readings of intermediate and long period surface waves (*e.g.* M2, Rg, LQ, LR) are only for the purpose of indicating the presence of a particular phase and not for use in data interpretations related to travel times. This is an important caveat which applies to all surface waves included in the GTDB.

Events were not re-located during the analysis. Instead, we kept the information as derived from the original source of the bulletin and only associated the observed signals on the available waveforms. If no waveform was available, then no arrival exists in the database for it. However, the reverse is not true. Waveforms were retained in the database for which no signal was observed.

Analysis Guidelines

Guidelines were modified and documented by the analyst as appropriate to each cluster. For this reason, GTDB users are encouraged to study the analysis notes before interpreting the results. The complete list of analysis guidelines followed for each cluster is included on the GTDB Web Site. Some examples of widely used guidelines are listed below.

- Secondary phases were added even if the first P arrival was unreadable.
- Phases with indistinct and/or ambiguous onsets were not added.
- Phases were timed on unfiltered traces whenever possible. It was often necessary to apply bandpass filters to optimize enhancement of the phase of interest.
- Phases identified as Sn were timed on horizontal channels if available, otherwise on well-recorded vertical channels.

When phases are consistently observed in a region with characteristics that are different from standard phases, they are defined in the analysis guidelines. In the following examples of analysis guidelines, the statements may be applicable to only a few clusters.

- A later-arriving intermediate period Rayleigh wave (10-14s) was identifed as Rx.
- An intermediate-period phase (12-15s) that recorded best on the vertical channels was labelled M2.
- An intermediate-period Rayleigh wave (10-13s) was identified as Rg.
- An intermediate-period phase (12-14s) that recorded best on the horizontal channels was identified as LQ.

Table 2. Results of Interactive Waveform Analysis

			Regional Phases (delta < 20 degrees)						
Dataset	events	phases	all	Pn	Pg	Sn	Lg	P	Regional Stations
ILPA/MAIO	195	1702	1570	507	124	65	369	103	MAIO, ILPA(5)
SPAIN	152	723	723	132	140	123	61	0	ESDC, PAB, MEB, TBT
GALILEE	50	1226	1226	104	521	2	106	0	ISN only
JSOP-I	24	85	78	21	11	16	20	0	ABKT, BGIO, KEG
JSOP-II	14	105	94	18	5	6	32	12	AAE, ABKT, ANTO, KIV, SAUDI(5)
SAUDI	258	3652	3200	685	124	388	697	260	AAE, AAK, ABKT, ANTO, KIEV, KIV, KMBO, NIL, SAUDI(6)
REB EQ's	125	1924	1045	281	23	198	128	104	ARU, BRVK, EIL, GEC2, JER, KBZ, KIV, KMBO, NIL, RAYN, KNET(9)
BATCH 1-3	116	1079	442	140	27	78	68	43	ABKT, ANTO, ARU, BGCA, EIL, ESDC, GERES, JER, KBZ, KIV, MLR, NIL, PAB
TOTALS:	934	10,496	8,378	1,888	975	856	1,481	522	

About the *Remark Table*

There are over 1500 lines of remarks associated with the last two datasets completed for this project (Saudi and REB-EQ). Many remarks are also associated with the other datasets. In general, these comments are qualitative, free-format lines of text written by the analyst. This section shows examples of the types of comments associated with the events.

Most of the comments are about the characteristics of the observed signal. Some examples of signal quality comments are listed below.

- "KMBO Sn onset unclear, not picked."
- "Sn onset too poor to read at RANI."
- "DBIC possible PcP but too weak, not picked."
- "EIL Lg onset unclear."
- "KMBO LR shows strong dispersion with 30-40 sec periods."

The first three comments listed above were noted by the analyst to let the user know that the observed phase was not strong enough to time sufficiently well to add to the database. The fourth comment indicates that the arrival was picked but was difficult to time.

A quality designation was associated with some of the phases with unclear onsets in the Saudi Dataset. This grading system is explained below:[16] [17]

phase	certainty	grade
P, Pn	within 2-4 seconds	C
P, Pn	within 4-6 seconds	D
S, Sn, Lg	within 3-6 seconds	C
S, Sn, Lg	within 6-9 seconds	D

These grades represent the analyst's best qualitative estimate of the accuracy of the time pick for a given arrival. Because the GTDB events are analyzed by geographic region, there is sufficient data redundancy to allow review and comparison of events. This data redundancy is what enables the analyst to learn expected signals for a given path and report qualitative remarks about them.

If an arrival does not carry a "qual" designation, then one can assume that the analyst believes the actual time of arrival occurs within a two-second window centered on the analyst time pick. Some of the small events include signals which are barely visible. If the signal could not be timed satisfactorily, then it was not added to the database. Instead, a comment in the *remark* table acknowledges the observation of the phase.

Some of the comments in the *remark* table relate to the event as a whole. Examples are:

[16] The definitions were changed for some regions to include a grade of "B" and make small changes in the certainty associated with the C and D grades. See Analyst Notes for each cluster on the GTDB Web Site.

[17] Toward the end of the project, these quality grades were stored in the qual field of the *arrival* table rather than the *remark* table.

- "Event is too small to read."
- "Appears to be marginally mislocated - by about 0.3 degrees."
- "Double event - mixed codas. Second event occurs about 65s later."
- "Reviewed Event Bulletin: evid = 973258."
- "REB reports depth of 13.7 km from depth phases at 4 stations."
- "Appears smaller than listed mb 4.0."

The first comment above indicates that the data were reviewed and no signal was visible on any available data. The second comment indicates that arrivals picked by the analyst do not match the event information precisely and that this difference may be due to location error. The fourth comment is a cross-reference to the pIDC's REB. By using the evid given, additional pIDC information may be available for the event.

Some examples of comments relating to waveform quality are listed below.

- "KMBO channels show high frequency noise bursts 41 sec after Pn."
- "SODA channels have large DC offsets."
- "NIL Sn clipped, not picked."
- "KBZ channels have many spikes."
- "NIL/SHN channel not available."
- "EIL channels are flat."
- "DAVOS/SHN,SHE channels begin 33 sec after P arrival."

Some of the examples refer to a single waveform, others to a single station. Again, these are qualitative remarks. We have not quantified spikes or data gaps. Only in a few cases did we even remove bad data. We chose to leave bad data in the database because different levels of quality are needed by different users. Data quality remarks are not guaranteed to be complete. In a few cases, when all the data collected from one station were bad, we would remove the data from the database, leaving the comments in the *remark* tables as a reference to the fact that the data were reviewed and were not useful.

For the ILPA/MAIO dataset, waveform quality comments were stored in the *wfedit* table. All other such comments are stored in the *remark* table.

Seismic Bulletins

The seismic bulletins are a way of summarizing information contained in the *origin*, *assoc*, *arrival* and *remark* table-files. The latter three tables are the result of the interactive waveform analysis.

GTDB bulletins are different from standard bulletins because the hypocenters listed were not derived from the arrivals listed. In other words, we did not re-locate the events based on the arrivals picked during the analysis. The parameter "ndef" listed with the *origin* information represents the number of defining phases in the original bulletin. The parameter "nass" is the number of GTDB phases associated with the event. Below the origin and arrival information for each event, the contents of the *remark* table are listed.

Because of their length[18], the bulletins are not reproduced in this report. The complete seismic bulletin for each region is listed on the GTDB Web Site. The bulletin for a few selected events from the N. Iran region of the REB-EQ Dataset is shown below[19].

```
GTDB: REB-EQ Dataset: Bulletin: N. Iran
origin time               lat    lon   dep  d  mb ndef nass etype  evid  author
 5/10/1997  8:37:14.363  32.90  60.05   0   g  4.1  19    5   eq    7101  REB

      sta   delta seaz  phase    arrival time             arid
      NIL   11.06 269.75 Pn      5/10/1997  8:39:55.272  103534
     RAYN   15.85  50.53 Pn      5/10/1997  8:40:59.271  103535
      KBZ   17.21 123.21 Pn      5/10/1997  8:41:16.541  103533
     GEC2   37.78  97.41 P       5/10/1997  8:44:33.945  103532
     BGCA   47.62  49.03 P       5/10/1997  8:45:53.619  103531

   Reviewed Event Bulletin:  evid = 1032120.
   Another aftershock appears 3m 10s later.

origin time               lat    lon   dep  d  mb ndef nass etype  evid  author
 5/10/1997  8:40:23.771  32.75  59.98   0   g  4.0  12    3   eq    7102  REB

      sta   delta seaz  phase    arrival time             arid
     RAYN   15.72  50.89 Pn      5/10/1997  8:44:08.995  103538
      KBZ   17.28 123.71 Pn      5/10/1997  8:44:27.995  103537
     BGCA   47.50  49.18 P       5/10/1997  8:49:04.848  103536

   Reviewed Event Bulletin:  evid = 1032122.
   Other aftershocks occur 3-4 minutes before and after this event.

   NIL  Pn onset unclear, not picked.
   GEC2 too small to read.

origin time               lat    lon   dep  d  mb ndef nass etype  evid  author
 5/10/1997 10:27:29.180  33.71  59.93  65   f  4.0  24    8   eq    7106  REB

      sta   delta seaz  phase    arrival time             arid
```

[18]There are over 16,000 lines in the seismic bulletins for the completed datasets.

[19]The complete bulletin is available at URL: http://es1.multimax.com/~gtdb/rebeq/niran.html

NIL	11.08	273.99	Pn	5/10/1997 10:30:04.239	103551
RAYN	16.22	47.90	Pn	5/10/1997 10:31:01.872	103552
RAYN	16.22	47.90	Sn	5/10/1997 10:33:55.347	103553
KBZ	16.59	121.42	Pn	5/10/1997 10:31:12.741	103549
KIV	16.84	121.66	P	5/10/1997 10:31:16.654	103550
GEC2	37.20	96.47	P	5/10/1997 10:34:34.638	103548
BGCA	47.89	48.00	P	5/10/1997 10:36:00.033	103546
DBIC	65.39	55.88	P	5/10/1997 10:38:04.295	103547

Reviewed Event Bulletin: evid = 1032190.
REB reports depth of 65 km, but event probably crustal. Hence, regional phase type Pn used for NIL and KBZ.

Instruments:
KBZ channels show frequent spikes and dropouts.
EIL channels are flat. REB reports P at 10:32:14.575.

origin time	lat	lon	dep	d	mb	ndef	nass	etype	evid	author
5/10/1997 23:35:36.813	33.04	60.10	0	g	4.3	22	8	eq	7120	REB

sta	delta	seaz	phase	arrival time	arid
RAYN	15.96	50.18	Pn	5/10/1997 23:39:21.467	103638
RAYN	15.96	50.18	LQ	5/10/1997 23:43:46.426	103640
RAYN	15.96	50.18	LR	5/10/1997 23:44:22.573	103639
KBZ	17.15	122.78	Pn	5/10/1997 23:39:38.867	103636
KIV	17.40	122.99	P	5/10/1997 23:39:40.404	103637
GEC2	37.72	97.19	P	5/10/1997 23:42:54.874	103635
BGCA	47.71	48.89	P	5/10/1997 23:44:15.279	103633
DBIC	65.43	56.63	P	5/10/1997 23:46:21.655	103634

Reviewed Event Bulletin: evid = 1032662.

KBZ Pn onset poor.
ESLA P onset unclear, not picked.

Instruments:
KBZ channels show a spike and dropout within seconds of P arrival.
EIL channels are flat. REB reports P at 23:40:34.7.

origin time	lat	lon	dep	d	mb	ndef	nass	etype	evid	author
5/13/1997 6:11:57.663	33.85	59.44	0	g	4.1	21	9	eq	7121	REB

sta	delta	seaz	phase	arrival time	arid
ABKT	4.22	164.88	Pn	5/13/1997 6:13:02.931	103642
ABKT	4.22	164.88	Pg	5/13/1997 6:13:18.550	103643
ABKT	4.22	164.88	Sn	5/13/1997 6:13:52.071	103644
ABKT	4.22	164.88	Lg	5/13/1997 6:14:13.441	103645
AAK	14.68	238.23	Pn	5/13/1997 6:15:16.323	103641
RAYN	15.97	46.64	Pn	5/13/1997 6:15:38.732	103649
KBZ	16.20	122.01	Pn	5/13/1997 6:15:44.883	103648
GEC2	36.79	96.70	P	5/13/1997 6:19:08.647	103647
BGCA	47.60	47.58	P	5/13/1997 6:20:33.428	103646

Reviewed Event Bulletin: evid = 1034994.

GEC2, BGCA, and DBIC record surface waves to different event.
EIL too small to read.

origin time	lat	lon	dep	d	mb	ndef	nass	etype	evid	author
5/14/1997 14:14:16.585	32.96	60.24	0	g	4.6	37	27	eq	7123	REB

sta	delta	seaz	phase	arrival time	arid
ABKT	5.26	160.18	Pn	5/14/1997 14:15:36.290	103679
ABKT	5.26	160.18	Pg	5/14/1997 14:15:56.316	103680
ABKT	5.26	160.18	Sn	5/14/1997 14:16:39.011	103681
ABKT	5.26	160.18	Lg	5/14/1997 14:17:03.857	103682
ABKT	5.26	160.18	Rg	5/14/1997 14:17:34.175	103683
NIL	10.89	269.97	Pn	5/14/1997 14:16:56.392	103695
NIL	10.89	269.97	Lg	5/14/1997 14:20:05.379	103696
NIL	10.89	269.97	LR	5/14/1997 14:20:24.786	103697
AAK	14.80	233.89	Pn	5/14/1997 14:17:44.856	103675
AAK	14.80	233.89	Sn	5/14/1997 14:20:21.725	103678
AAK	14.80	233.89	LR	5/14/1997 14:21:43.151	103677
AAK	14.80	233.89	Lg	5/14/1997 14:22:06.716	103676
RAYN	16.02	50.66	Pn	5/14/1997 14:17:55.334	103698
RAYN	16.02	50.66	LQ	5/14/1997 14:22:21.280	103701
RAYN	16.02	50.66	Lg	5/14/1997 14:22:32.628	103699
RAYN	16.02	50.66	LR	5/14/1997 14:22:54.549	103700
KIV	17.54	122.88	P	5/14/1997 14:18:20.863	103691
KIV	17.54	122.88	LR	5/14/1997 14:23:09.861	103692
EIL	21.81	74.83	P	5/14/1997 14:19:11.070	103686
EIL	21.81	74.83	S	5/14/1997 14:23:18.795	103687
EIL	21.81	74.83	LQ	5/14/1997 14:25:36.415	103688
MLR	29.09	103.43	P	5/14/1997 14:20:21.037	103693
MLR	29.09	103.43	PcP	5/14/1997 14:23:26.979	103694
GEC2	37.87	97.16	P	5/14/1997 14:21:35.806	103689
GEC2	37.87	97.16	PcP	5/14/1997 14:23:51.525	103690
BGCA	47.79	49.05	P	5/14/1997 14:22:55.908	103684
DBIC	65.54	56.73	P	5/14/1997 14:25:02.233	103685

Reviewed Event Bulletin: evid = 1036775.
ABKT Sn onset unclear.
ABKT Rg onset unclear.
EIL S observed with 0.03-0.1 Hz Causal BP filter.
MLR P onset weak.

Instrument:
KBZ channels degraded and begin 52 sec late.
MLR channel is degraded.

Summary of Completed Datasets

In this section, we summarize the individual datasets completed under the current project. The first seven are available from an anonymous FTP site[20]. The last dataset can be obtained by contacting the authors.

ILPA/MAIO: The waveform data are from two seismic stations located in Iran and operating in the late 1970's: The Iranian Long-Period Array (ILPA), located near Tehran, and MAIO, located 800 km east of ILPA. Based on USGS hypocenters regional to ILPA, we segmented the continuous waveform data for 273 events. Over 1,700 phases were timed, identified and associated with 195 events. Due to its wide (50 km) aperture, ILPA was not treated as an array in this analysis. Instead, the individual sites were all treated as separate stations. One nuclear explosion from the Azgir test site is included (12/18/78). Events occurred between May 1978 and October 1979. More details of this dataset are given in Chapter 2, beginning on page 31.

SPAIN: Based on the bulletin produced by the Instituto Geografico Nacional (IGN, Madrid) we identified 5 clusters of interest. Available waveform data for these events are primarily from stations PAB, MEB, and the Sonseca Array (ESDC). Two clusters are at the site of known mines and are believed to be quarry blasts. One event is a mine tremor. These events are about 1 degree distant from ESDC. Two clusters on the north coast of Africa are presumed earthquakes. Distances to ESDC are about 4.5 degrees. These events occurred between May 1993 and July 1995. More details of this dataset are given in Chapter 3, beginning on page 49.

GALILEE: The Geophysical Institute of Israel (GII) provided waveforms from the Israel Seismic Network (ISN). Twenty events were identified as quarry blasts, and 30 as earthquakes (Gitterman and van Eck, 1993). We used updated locations calculated by Gitterman *et al.* (1996). Events range in magnitude from ML 1.0 to ML 2.6, epicentral distances from less than 0.1 degree to 3 degrees, and depths from surface to 23 km. The largest of the events was recorded at 28 ISN stations, and the smallest at 4 ISN stations. Events occurred between October 1987 and May 1991. More details of this dataset are given in Chapter 4, beginning on page 67.

JSOP-I: Participating countries in the first experimental period of the Joint Seismic Observation Program (JSOP-I) were: Cyprus, Egypt, Israel, Jordan, Lebanon, Saudi Arabia, Turkey, and Yemen. Phase readings were exchanged, and the bulletin was produced at the European-Mediterranean Seismological Centre (EMSC, 1995). We retrieved waveforms from the IRIS DMC archives for 35 events. Arrivals were associated with 24 events, one-half of which are located near the Gulf of Aqaba. The JSOP-I experiment was conducted between September and November of 1994. More details of this dataset are given in Chapter 5, beginning on page 83.

[20]See page 29 for instructions.

JSOP-II: This dataset is based on the first three months of the JSOP-II bulletin which is currently being produced by EMSC for 1996. Out of 1230 events in that bulletin, over 1100 were aftershocks of the Ms 7.1 Gulf of Aqaba event of November 22, 1995. Because this aftershock series is represented in the Saudi Dataset (below), we collected data only for the events located outside the Gulf of Aqaba. The majority of the non-Aqaba events were contributed by Syria. For 46 Syrian events, we collected and analyzed all available regional data from IRIS. Useful signals were observable for only a handful of events due to the small magnitudes and lack of available near-regional data. Processing of another 12 non-Aqaba events contributed by other countries added another 7 events with associated phases. More details of this dataset are given in Chapter 5, beginning on page 83.

SAUDI: Waveform data from a temporary network of broadband seismometers sited in Saudi Arabia have recently been made available to the CTBT research community through the IRIS DMC. These data were collected primarily by researchers from UCSD, King Saud University and Boise State University (Vernon *et al.*, 1996). Based on the bulletins produced by the USGS and the IDC, we have identified over 300 events regional to the Saudi network which occurred on days when at least one Saudi station was operational. Events occurred between November 1995 and May 1996. Saudi network data have been supplemented with data from other stations from the IRIS archives. Events have been grouped into 12 geographical clusters. To date, 11 of these clusters are completed. One cluster comprises the aftershocks of the Gulf of Aqaba event. (The main shock of November 1995 occurred the day before the Saudi network became operational.) More details of this dataset are given in Chapter 6, beginning on page 103.

REB Earthquake Clusters: During Febuary and March of 1997, three earthquake sequences occurred in the Middle East and were reported in the REB. We collected all regional data from the pIDC and DMC archives for these earthquake clusters located in Turkmenistan, Pakistan, and Ethiopia. By combining pIDC data with IRIS data, and analyzing the events with emphasis on identification of later phases, we increased the number of regional phases associated with these events. Another four series of interest occurred in April and May. More details of this dataset are given in Chapter 7, beginning on page 139.

REB Batch 1-3: In addition to the above datasets, we have retrieved and analyzed about one gigabyte of waveform data from the pIDC and USGS data archive for events occurring in ME-NA in 1996. For the most part, these events do not have good regional station coverage. Only stations JER, NIL, KIV, and ABKT have significant numbers of regional phases. We did not supplement the regional data from IRIS DMC for these events. Batch 1 includes two Lop Nor nuclear explosions (6/96, 7/96) and a German mine tremor (9/96). Batch 2 of this dataset is an aftershock series related to the Cyprus event of October, 1996. It has been included with the REB-EQ Dataset. Batch 3 comprises 73 events resulting from a systematic attempt to retrieve data for ME-NA events based on the REB. The time-period of Batch 3 is from September through December of 1996. These data were delivered directly to LLNL for inclusion in their regionalization database. Although Batch 1 and Batch 3 are not currently available from the GTDB FTP site, they can be obtained from the authors. This dataset is not detailed in the current report.

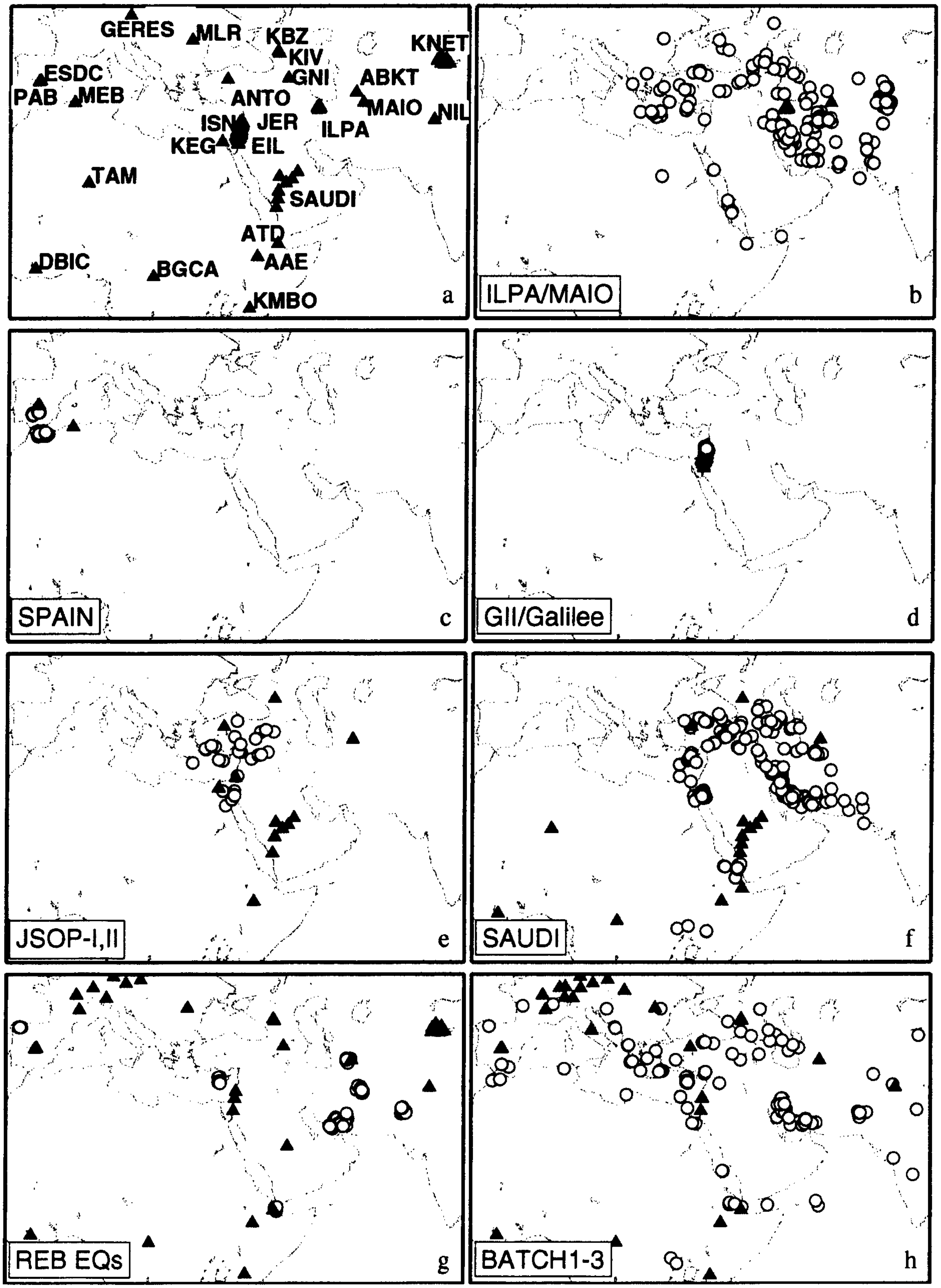


Figure 3: GTDB Datasets. a) stations; b-g) completed datasets available via anonymous FTP; h) additional data. Map boundaries are the same as in Figure 1.

Documentation

The GTDB Web Site includes the most comprehensive and up-to-date information on available datasets. Reach it through the URL listed below.

`http://es1.multimax.com/~gtdb/index.html`

There are over 400 different HTML documents (Web pages) available through the GTDB Web Site. This section of the report is a tour of the pages relating to the Saudi Dataset as an example of the type of documentation available from the Web Site. Pages relating to other datasets differ slightly.

The GTDB Home Page is represented in Figure 4. On the home page, there are short descriptions of and links to each of the completed datasets. Each dataset in turn has its own home page with links to documentation for each region in the dataset. Figure 5 shows the Saudi Home Page. Figures 6 and 7 show portions of the Hormuz Region page.

The region pages are the heart of the information on the GTDB Web site. From the region pages, the user can get all the information available for a particular region. The region pages were designed with two objectives in mind. First, to provide enough information to help the user know whether the data are suitable for the particular research project before the data are down-loaded. The second design objective is to provide an easy interface to down-load single event directories.[21] The three major components of the region page are outlined below:

Map The location map for the region. Links below the map include:

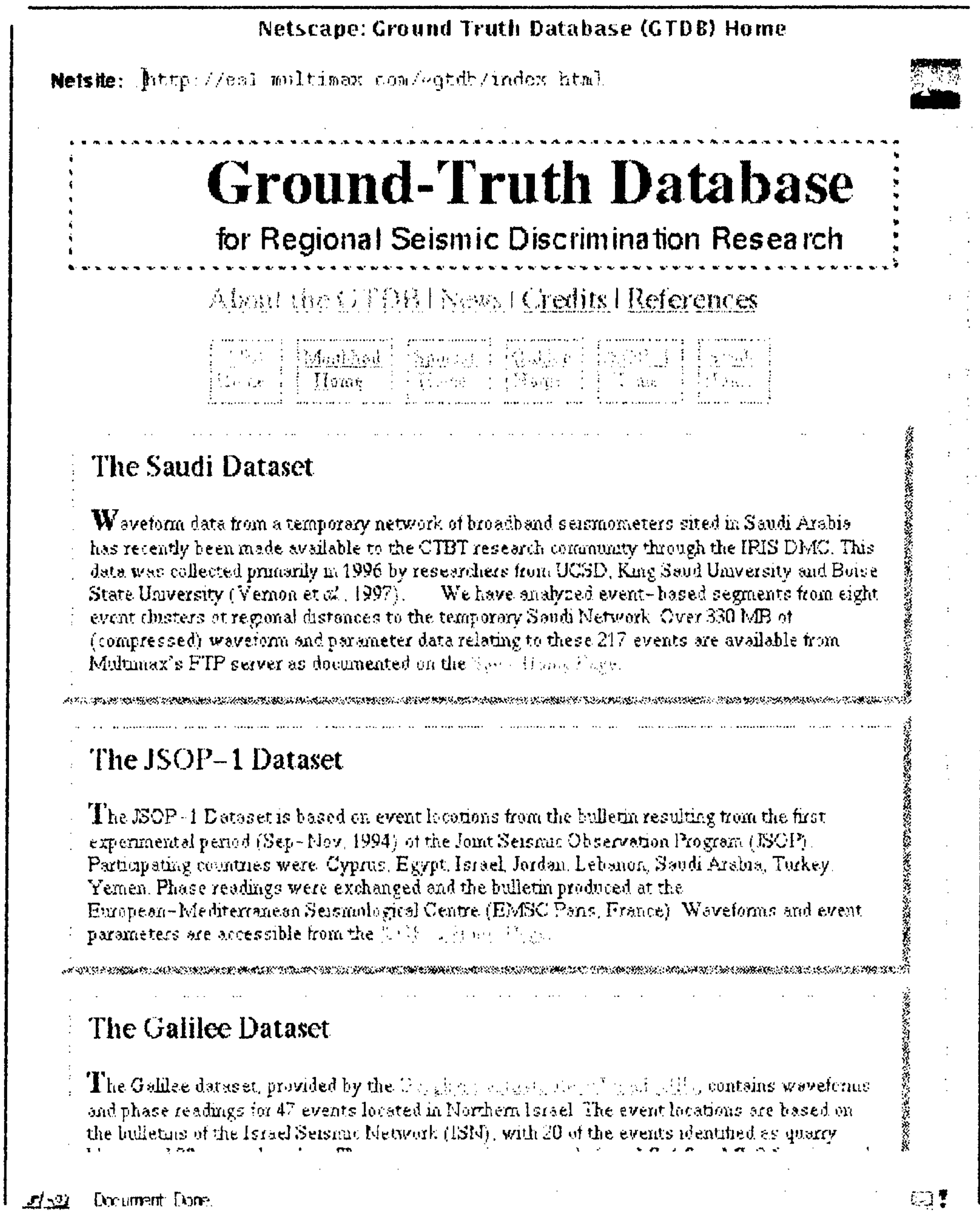
- Data Summary - description of waveform data available for the region;
- Event List - listing from *origin* table only. Event Lists from all datasets are included in this report. See page 113 for the Hormuz Region Event List;
- Results - Here are essentially the results of the seismic analysis in visual form. An example is shown in Figure 8. (The results of analysis are shown in text form in the seismic bulletins.);
- Get Data - a tutorial on how to get the data. (Similar to page 29 of this report.);
- About This Page - a description of the region pages.

Analysis Notes These analyst comments may be critical for correctly using the *assoc* and *arrival* tables. The "Sample Plots" link goes to a page showing either typical or interesting examples of waveforms for selected events.

Seismic Bulletin A listing of event parameters (*origin* table) and arrivals (*arrival* and *assoc* tables). Below the arrivals are the analyst's comments about the signals and/or waveform data (*remark* table). A segment of the seismic bulletin for the Hormuz Region of the Saudi Dataset is shown in Figure 7.

The evid listed in the seismic bulletin is a hot link which initiates an FTP process to copy the event directory for the selected event to the user's machine. (See section "How to Get the Data" on page 29 of this report.)

[21] Another way to get data is to go directly to the FTP site and down-load all the event directories for a region at once. See page 29 for instructions.



Netscape: Ground Truth Database (GTDB) Home

Netsite: http://esi.multimax.com/~gtdb/index.html

Ground-Truth Database

for Regional Seismic Discrimination Research

About the GTDB | News | Credits | References

The Saudi Dataset

Waveform data from a temporary network of broadband seismometers sited in Saudi Arabia has recently been made available to the CTBT research community through the IRIS DMC. This data was collected primarily in 1996 by researchers from UCSD, King Saud University and Boise State University (Vernon et al., 1997). We have analyzed event-based segments from eight event clusters at regional distances to the temporary Saudi Network. Over 330 MB of (compressed) waveform and parameter data relating to these 217 events are available from Multimax's FTP server as documented on the Saudi Home Page.

The JSOP-1 Dataset

The JSOP-1 Dataset is based on event locations from the bulletin resulting from the first experimental period (Sep-Nov, 1994) of the Joint Seismic Observation Program (JSOP). Participating countries were: Cyprus, Egypt, Israel, Jordan, Lebanon, Saudi Arabia, Turkey, Yemen. Phase readings were exchanged and the bulletin produced at the European-Mediterranean Seismological Centre (EMSC Paris, France). Waveforms and event parameters are accessible from the JSOP Home Page.

The Galilee Dataset

The Galilee dataset, provided by the [illegible], contains waveforms and phase readings for 47 events located in Northern Israel. The event locations are based on the bulletins of the Israel Seismic Network (ISN), with 20 of the events identified as quarry

Document: Done.

Figure 4: The Home Page of the GTDB Web Site. The links across the top lead to general information about the GTDB. For each completed dataset, there is a short description and a link to the related Home Page. For example, when the "Saudi Home Page" is selected, the Web page shown in Figure 5 is loaded.

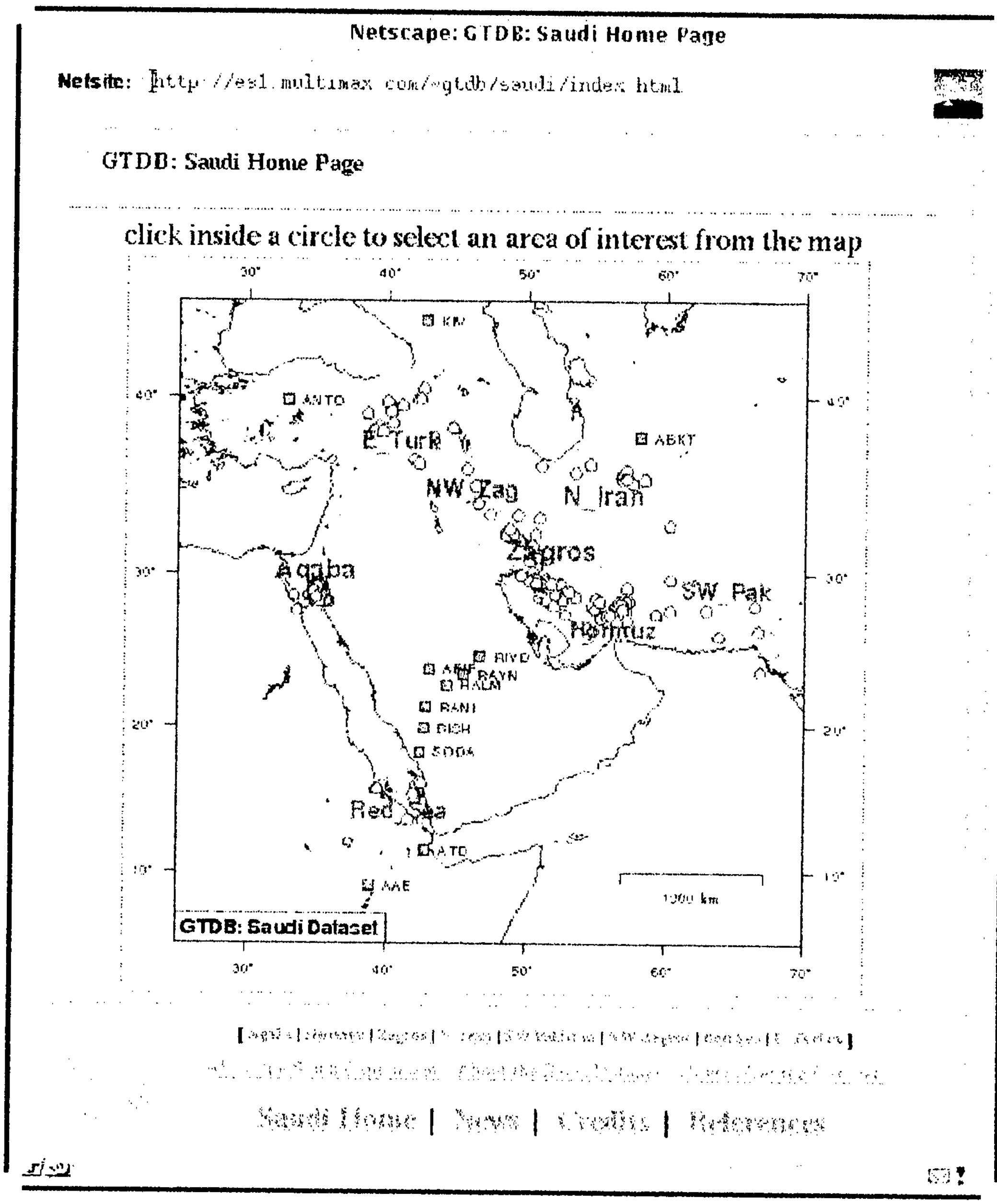


Figure 5: The Saudi Home Page. The map is a live imagemap providing links to pages covering each region of the Saudi Dataset. For example, when the Hormuz region is selected, the Web page shown in Figures 6 and 7 is loaded. (Links to the regions are repeated below the map for text-only browsers.) Below the map are links to general information about the Saudi Dataset (e.g. "About the Saudi Experiment" etc.). Changes made to any of the event directories in the Saudi Dataset are noted in the "News" document.

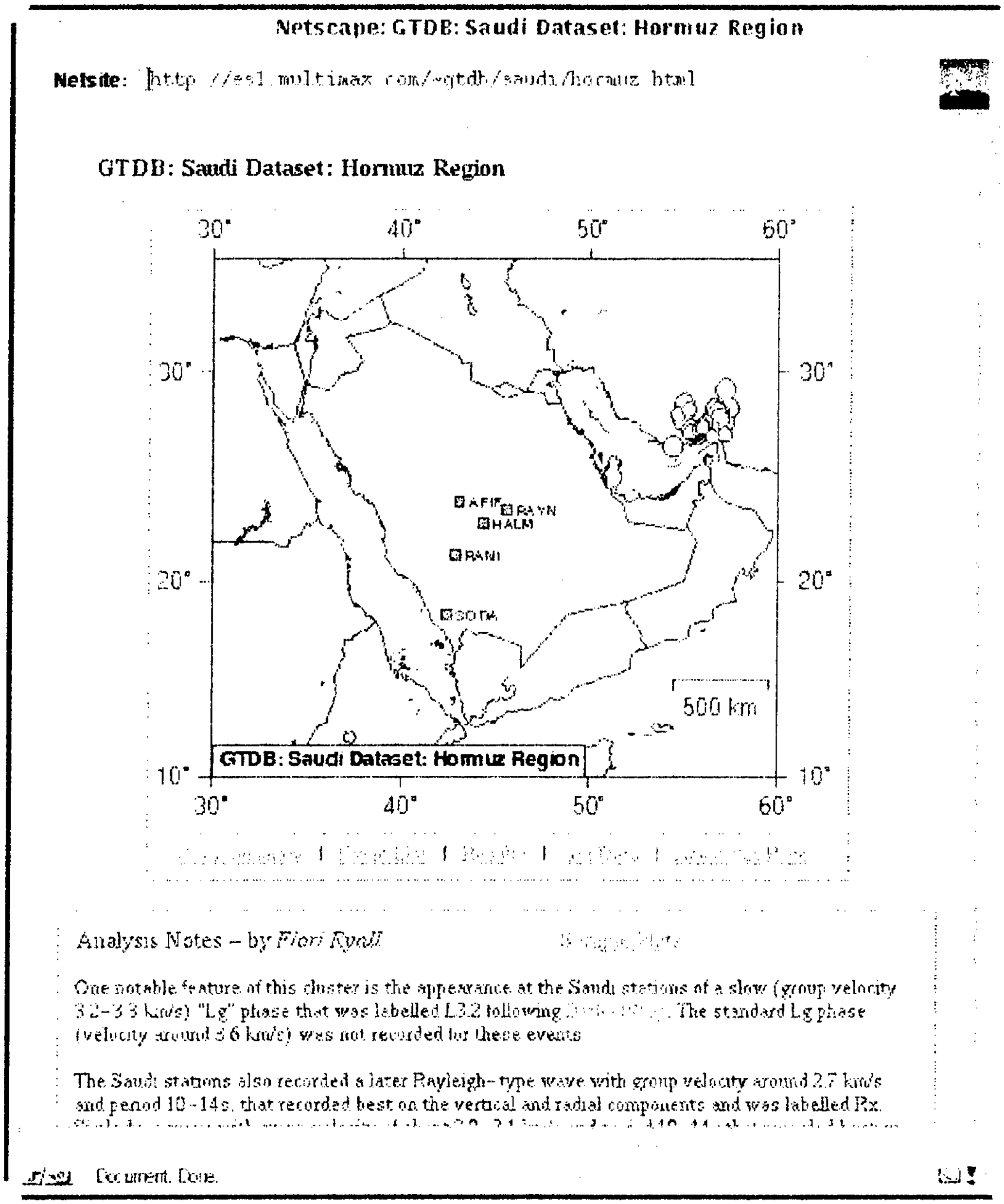


Figure 6: Sample region page from the GTDB Web Site describing the Hormuz Region of the Saudi Dataset. Links below the map (e.g. "Data Summary") are described on page 22 of this report. The "Results" document is a graphical representation of all arrivals associated with all events in the region. An example is shown in Figure 8. Below the map and "Analysis Notes" is the seismic bulletin resulting from analysis of this region (see excerpt in Figure 7). The link to "Sample Plots" loads images of waveforms from selected events. Sample plots from the Saudi Dataset begin on page 118 of this report.

Netscape: GTDB: Saudi Dataset: Hormuz Region

File Edit View Go Bookmarks Options Directory Window Help

Netsite: http://esl.multimax.com/~gtdb/saudi/hormuz.html

Caveat: Readings of intermediate and long period surface waves (Rg, LQ, LR) are only for the purpose of indicating the presence of a particular phase and not for use in data interpretations related to traveltime plots.

GTDB: Saudi Dataset: Bulletin: Region Hormuz

```
origin time                          lat    lon    dep  d  mb ndef nass etype  evid
1995337 12/03/1995 15:19:40.218    28.07  54.65    0  g  3.9   8    6    u

    sta   delta  seaz phase     arrival time              arid
   RAYN    9.41  59.18 Pn      12/03/1995 15:21:58.971    13801
   RAYN    9.41  59.18 Sn      12/03/1995 15:23:40.704    13802
   HALM   10.69  58.61 Pn      12/03/1995 15:22:16.062    13803
   HALM   10.69  58.61 Sn      12/03/1995 15:24:15.399    13804
   AFIF   11.22  65.90 Sn      12/03/1995 15:24:31.253    13805
    KIV   18.56 144.92 P       12/03/1995 15:24:09.258    13806

  KIV P - C

origin time                          lat    lon    dep  d  mb ndef nass etype  evid
1995338 12/04/1995 19:35:36.100    27.83  54.88   33  N  4.8  26   29    u

    sta   delta  seaz phase     arrival time              arid
   RAYN    9.49  61.01 Pn      12/04/1995 19:37:51.646    13816
   RAYN    9.49  61.01 Sn      12/04/1995 19:39:33.431    13817
   RAYN    9.49  61.01 L3 2    12/04/1995 19:41:01.680    13818
   RAYN    9.49  61.01 LQ      12/04/1995 19:41:23.656    13825
   RAYN    9.49  61.01 Rg      12/04/1995 19:41:51.000    13827
   ABKT   10.46 195.97 Pn      12/04/1995 19:38:03.602    13829
   ABKT   10.46 195.97 Lg      12/04/1995 19:41:04.276    13830
   ABKT   10.46 195.97 LQ      12/04/1995 19:41:43.694    13834
   ABKT   10.46 195.97 Rg      12/04/1995 19:42:04.990    13831
   HALM   10.77  60.23 Pn      12/04/1995 19:38:08.764    13807
   HALM   10.77  60.23 Sn      12/04/1995 19:40:06.821    13808
   HALM   10.77  60.23 L3 2    12/04/1995 19:41:43.616    13809
   AFIF   11.34  67.36 Pn      12/04/1995 19:38:16.001    13810
   AFIF   11.34  67.36 Sn      12/04/1995 19:40:20.256    13811
   AFIF   11.34  67.36 L3 2    12/04/1995 19:41:48.923    13812
   AFIF   11.34  67.36 LQ      12/04/1995 19:42:23.841    13823
   RANI   12.79  56.94 Pn      12/04/1995 19:38:36.390    13813
   RANI   12.79  56.94 Sn      12/04/1995 19:40:57.865    13814
```

Figure 7: Sample region page from the GTDB Web Site describing the Hormuz Region of the Saudi Dataset. This page shows part of the seismic bulletin resulting from analysis of the Hormuz region of the Saudi Dataset. The evids (e.g. 400 and 401) are links to the event directories. When selected, the evid link initiates an FTP process which will copy the event directory to the user's machine. Contents of the event directories are described on page 10 of this report.

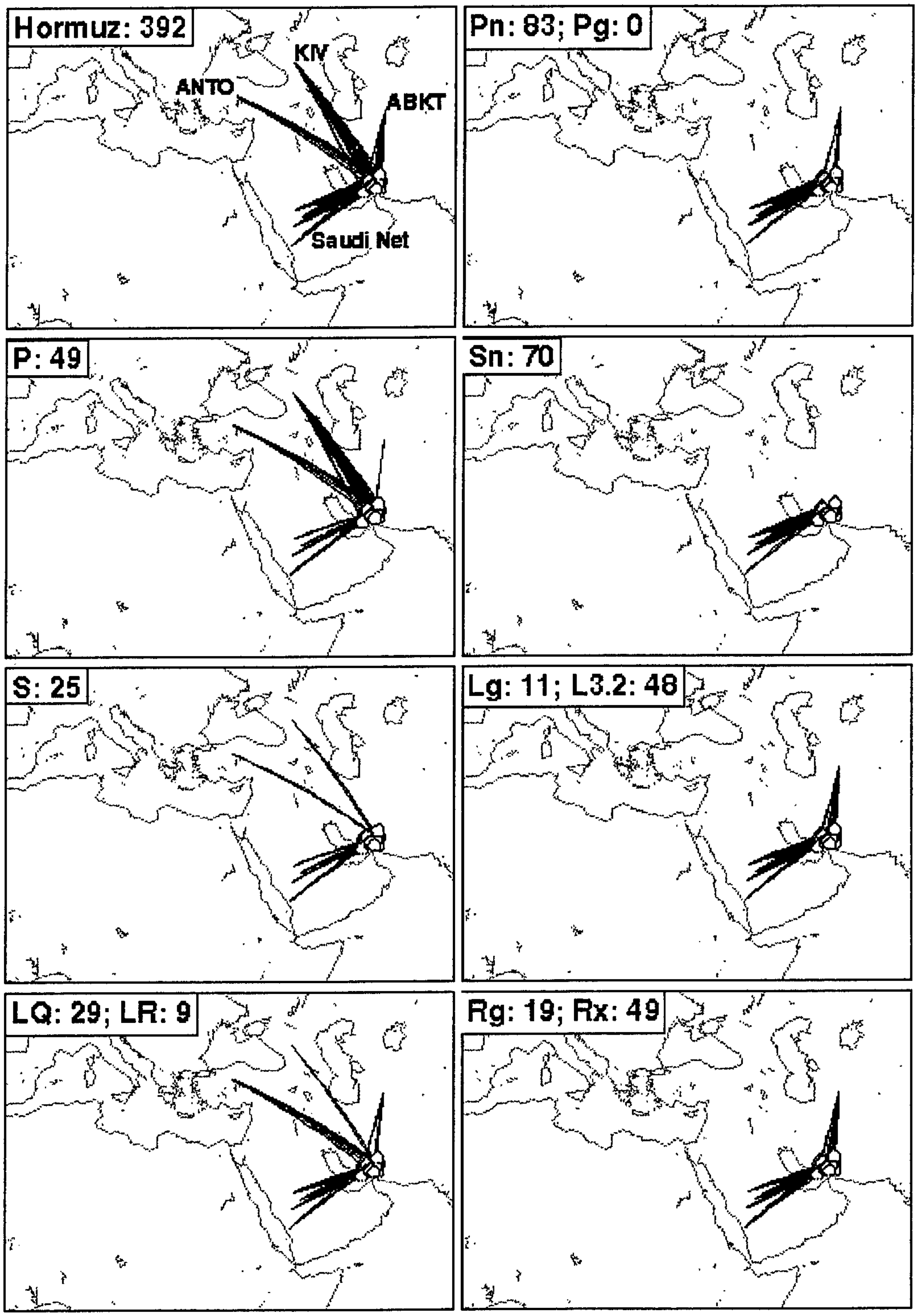


Figure 8: Hormuz Path Map. This is the document loaded by the "Results" link from the Hormuz Region Page shown in Figure 6. It is essentially a graphical representation of the *assoc* table. The plot in the upper-left corner shows all 392 observed paths for the Hormuz region. This page was designed to answer the question, "Which phases are observed at which stations for this region?"

In addition to the documentation on the Web Site, several reports have been generated for this project:

Grant, L., C. Carabajal (1995). Ground-Truth Database for Regional Seismic Identification Research *Proceedings of the* 17^{th} *Annual Seismic Research Symposium on Monitoring a Comprehensive Test Ban Treaty,* ed. J. Lewkowicz, J. McPhetres, D. Reiter, PL-TR-95-2108, ADA310037, 758-766.

Grant, L., F. Ryall, I. Henson, W. Rivers (1996). Ground Truth Database for Seismic Discrimination Research *Proceedings of the* 18^{th} *Annual Seismic Research Symposium on Monitoring a Comprehensive Test Ban Treaty,* ed. J. Lewkowicz, J. McPhetres, D. Reiter, PL-TR-96-2153, ADA313692, 997-1006.

Grant, L., R. Wagner, F. Ryall, I. Henson, W. Rivers (1997). Ground Truth Database for Regional Seismic Discrimination Research in the Middle East and North Africa, *Proceedings of the* 19^{th} *Annual Seismic Research Symposium on Monitoring a Comprehensive Test Ban Treaty,* ed. M. Shore, R.S. Jih, A. Dainty, J. Erwin, PE-35145F, 867-876.

Grant, L., F. Ryall, W. Rivers (1996). Ground Truth Database: ILPA/MAIO Handbook, Phillips Laboratory Report PL-TR-96-2236, ADA319155.

Henson, I. and L. Grant (1996). A Guide to ReqData: Automated Requesting and Parsing of GSE Formatted Data, Phillips Laboratory Report PL-TR-96-2272, ADA319134.

How to Get the Data

There are three ways to receive copies of the GTDB. In the examples below, retrieval of the Saudi Dataset is shown. Other datasets can be obtained in similar ways.

- Individual event directories can be FTP'd directly from the region pages of the GTDB Web Site. The procedure below will copy one event to your machine.

  Go to the Saudi Home Page
  Select a region of interest from the map
  Review the seismic event bulletin below the map
  Select the evid of the event to copy (by FTP) to your site

- To down-load larger groups of event directories, you may connect directly to Multimax's anonymous FTP site. To down-load all events from the Hormuz region, for example, follow the steps below.

  ftp es2.multimax.com
  (username is "anonymous"; password is your e-mail address)
  cd pub/gtdb/saudi/hormuz
  bin
  prompt
  mget *.Z
  quit

  This procedure will copy 26 events (26 event directories, for a total of 33 MB) to your machine.

- Copies of the datasets can also be obtained on Exabyte tape. Send a new, 8 mm Data Cartridge to the address listed below and a tape containing the requested dataset will be sent to you.

  Lori Grant
  Multimax, Inc.
  1441 McCormick Drive
  Largo, MD 20774

  Tapes of the GTDB datasets were submitted to the Funding Agency with this report.

Chapter 2

The ILPA/MAIO Dataset

The focus of this dataset was to utilize data from the Iranian Long-Period Array (ILPA) which operated near Tehran in the late 70's. Data from another Iranian station, MAIO, were merged with the ILPA data.

Based on hypocenters regional to ILPA, we segmented the continuous waveform data into 273 event directories. Analysis of these events resulted in the association of over 1,700 phases with 195 of the events. Figure 9 shows station and event locations. Events occurred between May 1978 and October 1979. One nuclear explosion from the Azgir test site is included (Region 2, ev230364, 12/18/78).

For details about the construction of this dataset and sample plots of analysis observations, see Grant *et al.*, 1996b. To obtain this data, or to preview the seismic bulletins resulting from analysis, refer to the GTDB Web Site at the URL on page 22.

About the Iranian Long-Period Array and MAIO

The Iranian Long-Period Array (ILPA) was installed in 1975 and 1976 by Texas Instruments for the Albuquerque Seismological Center (ASC) with cooperation from the University of Tehran Institute of Geophysics (UTIG).

Seven stations, arranged in a hexagonal pattern of about 50 km aperture, recorded both long-period (1 samp/sec) and short-period (20 samp/sec) continuous data on Teledyne Geotech KS-36000 instruments. Figure 10 shows the ILPA site map. Sites 1 and 7 were equipped with 3-component sensors. Based on experience by Rodgers *et al.*, (1997), data were excluded from sites 5 and 6 because these traces were flat.

Although we have found no documentation summarizing the experiment as a whole, two reports about the installation procedures are available. The second report listed below includes SP and LP response curves for each of the 7 sites.

- Installation Report for Iranian Long-Period Array, prepared for Albuquerque Seismological Center, USGS, Contract No. 14-08-0001-14031, 15 February 1977, Texas Instruments Inc.

- Iranian Long-Period Array Final Report, prepared for Albuquerque Seismological Center, USGS, Contract No. 14-08-0001-14031, 8 April 1977, Texas Instruments Inc.

We obtained the continuous ILPA waveform data in the form of tapes from the Center for Monitoring Research (CMR). These data had been previously processed into CSS3.0 format

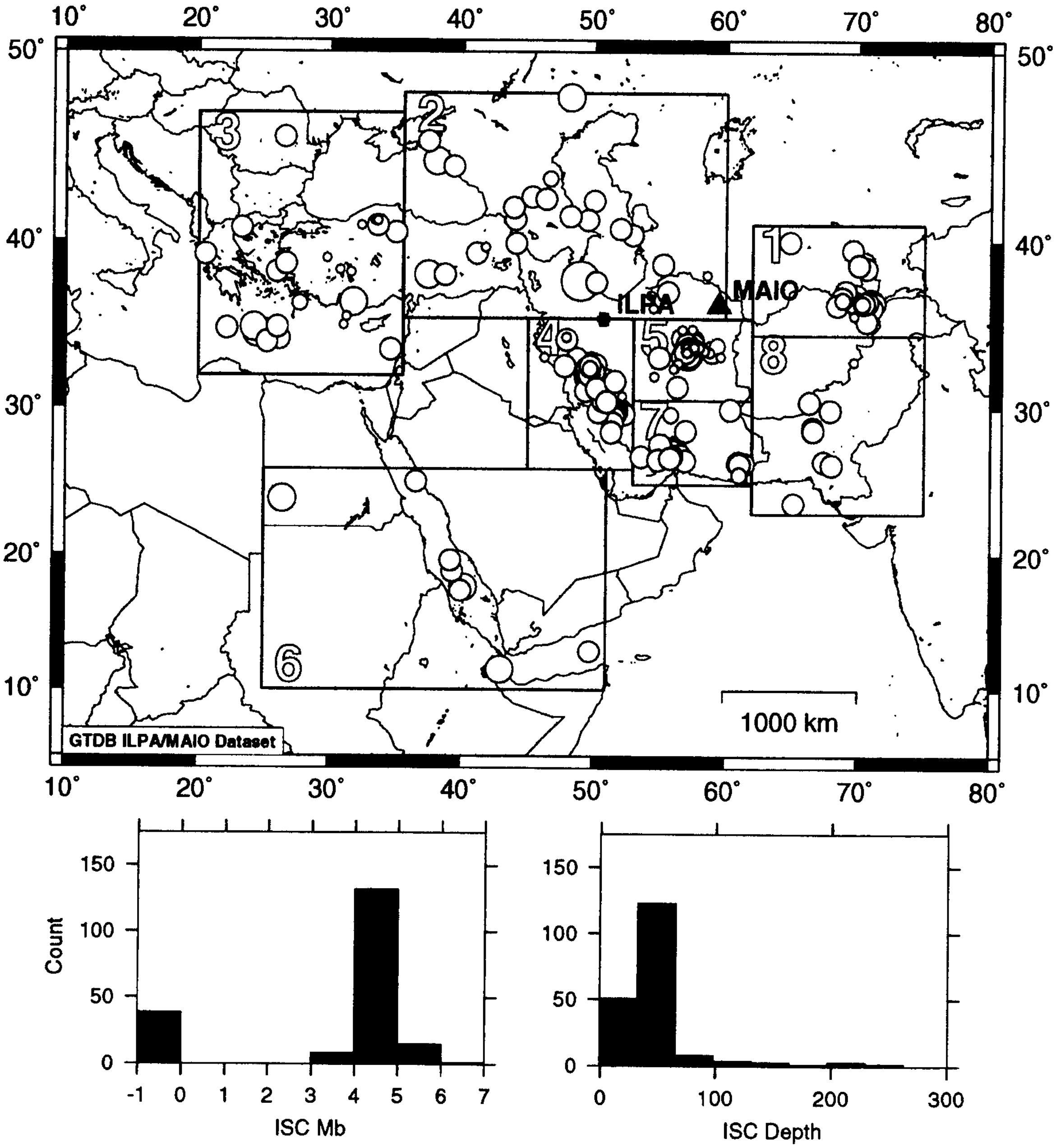


Figure 9: Location map of GTDB ILPA/MAIO data set. MAIO is approximately 800 km east of ILPA. For each of the 195 events shown on the map, there is at least one signal recorded on ILPA. About 61 of these events also have an associated phase at MAIO. An additional 78 events are not shown on the map because they were too small to record a signal at ILPA. Waveform data for these events are nevertheless included in the database.

by Teledyne Geotech. The *wfdisc*.calib field is the calibration factor required to convert the counts in the binary data file to displacement in nanometers. For the ILPA data, this number is 1.0 because the data are already converted to displacement. The continuous ILPA data are now available from the IRIS DMC.

Station MAIO (Mashhad, Iran) was operated by Albuquerque Seismological Lab between 3 October 1975 and 11 October 1978, employing a Teledyne Geotech KS-36000 borehole seismometer. MAIO is located approximately 800 km east of ILPA.

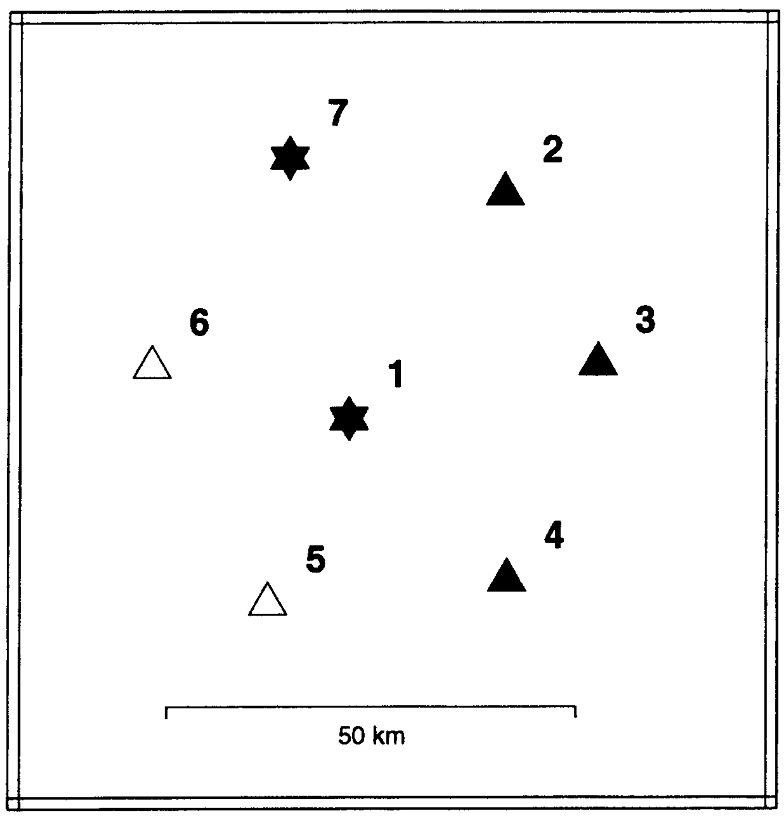


Figure 10: ILPA Site Map. Seven stations, arranged in a hexagonal pattern of about 50 km aperture recorded both long-period (1 samples/sec) and short-period (20 samples/sec) continuous data on Teledyne Geotech KS-36000 instruments. Sites 1 and 7 were equipped with 3-component sensors. Based on experience by Rodgers *et al.*, (1997), data were excluded from sites 5 and 6 because these traces were flat.

Construction of the ILPA/MAIO Event Directories

Events to be extracted from the continuous ILPA waveforms were selected from the USGS/ISC bulletin[22] based on query boundaries of:

- origin date between 16 May 1978 and 10 October 1979;
- latitude between 14.4N and 55.5N;
- longitude between 30.7E and 70.7E;
- no restriction on depth or magnitude.

That query returned 614 events. Another 21 events, which fell outside the query boundaries, but which were used in an earlier study, were added to the list.[23] A Datascope program (Quinlan, 1995) was used to compare the 635 targeted origins with the existing ILPA waveforms and to extract event segments. About 50% of the input origins were successfully recovered. This low success rate is partly due to gaps in the waveform coverage of the short-period ILPA channels[24] and partly due to our inability to read the first tape in the series.

Station MAIO, (Mashhad, Iran), was operated by Albuquerque Seismological Lab between 3 October 1975 and 11 October 1978, employing a Teledyne Geotech KS-36000 borehole seismometer. The overlap between the segmented MAIO waveforms, obtained from IRIS, and the available continuous ILPA data was 84 days (July-October, 1978). For 61 of the 273 extracted ILPA events, we were able to add waveforms from station MAIO.

Interactive Waveform Analysis

Before analysis, events were grouped into the eight geographic regions[25] outlined in Figure 9. Analysis then proceeded by region.

Over 1700 phases were timed and identified on the ILPA and MAIO waveforms.[26] Amplitude and period of the phases were not measured, and no data processing was performed on the arrivals.

Standard regional phases Pn, Pg, Sn, Lg, and Rg are observed in regions 2, 4, 5, and 7, where average distances are between 5 and 10 degrees. P and S are observed in regions 1, 3, 6, and 8, where the average distances are between 15 and 20 degrees and some events are deep.

[22]The query was performed on the "EVENTS" database account at CMR.

[23]A previous dataset of 100 ILPA events created by Rodgers *et al.* (1994) excluded events with no magnitude estimate. One reason for re-segmenting the ILPA data for this project was to emphasize regional waveforms by extracting more of the smaller events.

[24]Although ILPA data are continuous, long gaps (on the order of days) exist.

[25]The regions do not necessarily correspond to tectonic boundaries.

[26]Due to its large aperture (50 km), ILPA was not treated as an array; each site was treated individually.

Event Lists

In the event listings that follow, the origin time, latitude, longitude, depth, and mb are defined by the institution listed in the author field. The parameter, ndef, represents the number of defining phases used by author to define the event. The parameter, nass, is the number of GTDB phases associated with the event. For events with nass equal to zero, data were reviewed but no signal was strong enough to be timed and identified. Waveforms for these events are nevertheless retained in the database. The evid field in the lists is the same as the evid in the "EVENTS" database account at the CMR.

The event type field, etype, is "u" (unknown) for most of these events. One event from region 2 is labeled "nu" (nuclear) based on its presence in the "NUCLEAR" database account at CMR. Sweeney (1996) has identified four of the events in region 5 as "aftershocks of the Ms 7.4 Tabas-e-Golshan earthquake of 9/16/1978" based on a paper by Berberian (1982). We have updated the locations and author field of those 4 events and identified them as "known earthquakes" (*origin*.etype=eq) in the *origin* table-file.

GTDB: ILPA/MAIO Dataset: Region 1

origin time			lat	lon	dep	mb	ndef	nass	etype	evid	author
1978200	7/19/78	17:50:19.930	35.70	69.68	104	-9.0	5	1	u	223328	USGS/T/ISC
1978208	7/27/78	8:15:13.010	36.92	69.89	16	4.7	53	10	u	223775	USGS/T/ISC
1978209	7/28/78	19:23:44.220	37.63	70.22	33	3.8	5	0	u	223843	USGS/T/ISC
1978213	8/01/78	6:20:42.370	36.04	70.61	89	5.0	72	7	u	224006	USGS/T/ISC
1978215	8/03/78	2:25:14.170	36.44	71.25	249	4.3	64	7	u	224103	USGS/T/ISC
1978219	8/07/78	8:29:39.000	36.00	70.30	160	-9.0	-1	0	u	224277	USGS/T/ISC/RL
1978223	8/11/78	12:47:09.300	35.96	70.12	91	4.6	37	5	u	224446	USGS/T/ISC
1978224	8/12/78	1:07:40.560	37.04	69.61	33	4.1	7	0	u	224464	USGS/T/ISC
1978224	8/12/78	16:36:08.000	36.80	69.20	96	-9.0	-1	0	u	224482	USGS/T/ISC/RL
1978225	8/13/78	2:24:47.830	36.18	71.08	135	4.0	14	7	u	224495	USGS/T/ISC
1978229	8/17/78	1:29:19.980	36.10	69.04	140	3.7	7	0	u	224674	USGS/T/ISC
1978230	8/18/78	8:43:47.670	36.65	68.79	33	3.7	13	4	u	224710	USGS/T/ISC
1978232	8/20/78	19:28:03.000	35.70	69.40	96	-9.0	-1	0	u	224836	USGS/T/ISC/RL
1978232	8/20/78	22:30:56.680	36.26	70.61	242	3.3	8	0	u	224847	USGS/T/ISC
1978237	8/25/78	11:33:57.500	35.62	69.98	176	-9.0	5	0	u	225059	USGS/T/ISC
1978241	8/29/78	4:46:48.620	35.38	70.62	159	4.0	9	4	u	225202	USGS/T/ISC
1978243	8/31/78	8:07:21.280	38.83	70.46	24	4.2	20	1	u	225307	USGS/T/ISC
1978278	10/05/78	8:41:27.000	36.30	70.70	-9	-9.0	-1	0	u	226888	USGS/T/ISC/RL
1978296	10/23/78	8:07:31.600	36.48	70.95	183	5.6	353	3	u	227674	USGS/T/ISC
1978299	10/26/78	17:42:57.850	36.57	70.08	279	-9.0	5	0	u	227815	USGS/T/ISC
1978301	10/28/78	4:32:39.460	36.67	69.68	183	-9.0	5	0	u	227872	USGS/T/ISC
1978306	11/02/78	15:34:10.670	36.51	70.60	204	3.9	13	0	u	228117	USGS/T/ISC
1978306	11/02/78	18:05:55.140	36.15	70.42	71	-9.0	6	0	u	228120	USGS/T/ISC
1978308	11/04/78	2:17:29.670	35.39	69.83	195	3.5	10	0	u	228178	USGS/T/ISC
1978320	11/16/78	22:27:54.000	36.60	70.60	190	-9.0	-1	0	u	228755	USGS/T/ISC/RL
1978321	11/17/78	12:59:31.370	38.49	70.64	0	4.9	100	9	u	228785	USGS/T/ISC
1978321	11/17/78	18:14:10.000	36.60	70.70	160	-9.0	-1	0	u	228792	USGS/T/ISC/RL
1978321	11/17/78	22:05:02.000	36.60	70.70	160	-9.0	-1	0	u	228805	USGS/T/ISC/RL
1978322	11/18/78	4:30:19.000	36.30	70.10	160	-9.0	-1	0	u	228816	USGS/T/ISC/RL
1978326	11/22/78	9:47:32.000	35.60	69.70	160	-9.0	-1	0	u	228999	USGS/T/ISC/RL
1978328	11/24/78	22:32:04.000	35.90	70.30	96	-9.0	-1	0	u	229117	USGS/T/ISC/RL
1978332	11/28/78	19:40:11.000	36.30	70.60	96	-9.0	-1	0	u	229311	USGS/T/ISC/RL
1978347	12/13/78	18:14:48.000	36.00	70.00	96	-9.0	-1	0	u	230176	USGS/T/ISC/RL
1978353	12/19/78	21:47:00.940	36.09	70.59	145	-9.0	6	0	u	230430	USGS/T/ISC
1978354	12/20/78	21:57:39.000	36.00	69.30	223	-9.0	-1	0	u	230478	USGS/T/ISC/RL
1978362	12/28/78	21:50:11.000	37.40	70.00	96	-9.0	-1	0	u	230881	USGS/T/ISC/RL
1979008	1/08/79	17:05:17.000	36.56	70.35	160	-9.0	5	0	u	231361	USGS/T/ISC
1979140	5/20/79	12:29:41.520	39.55	69.56	40	4.2	23	4	u	237714	USGS/T/ISC
1979144	5/24/79	7:57:17.760	36.47	69.81	220	4.2	24	1	u	237922	USGS/T/ISC
1979145	5/25/79	7:52:18.620	37.18	69.04	33	4.1	8	5	u	237977	USGS/T/ISC
1979146	5/26/79	20:11:56.480	36.76	68.77	53	4.3	33	4	u	238061	USGS/T/ISC
1979155	6/04/79	12:15:36.660	37.67	70.21	42	4.1	18	0	u	238558	USGS/T/ISC
1979158	6/07/79	6:44:39.370	40.01	64.83	33	4.1	7	2	u	238694	USGS/T/ISC
1979158	6/07/79	13:46:43.830	36.33	68.40	40	4.5	37	2	u	238714	USGS/T/ISC
1979177	6/26/79	7:39:41.970	40.13	63.55	52	4.1	19	0	u	239805	USGS/T/ISC
1979194	7/13/79	0:12:19.300	36.47	70.69	33	3.7	4	0	u	240590	USGS/T/ISC
1979202	7/21/79	4:59:46.930	36.52	70.69	235	4.6	92	6	u	240987	USGS/T/ISC
1979220	8/08/79	3:22:09.140	36.46	70.44	202	4.3	31	3	u	241888	USGS/T/ISC
1979226	8/14/79	11:46:11.610	36.42	70.32	226	3.8	12	3	u	242225	USGS/T/ISC
1979226	8/14/79	20:50:09.920	38.68	70.06	44	4.1	21	6	u	242243	USGS/T/ISC
1979227	8/15/79	20:04:52.910	36.02	70.40	238	3.5	9	0	u	242290	USGS/T/ISC
1979231	8/19/79	9:13:54.180	37.63	68.65	33	3.6	4	0	u	242474	USGS/T/ISC

GTDB: ILPA/MAIO Dataset: Region 2

origin time			lat	lon	dep	mb	ndef	nass	etype	evid	author
1978201	7/20/78	10:20:24.760	38.66	55.24	33	4.3	9	8	u	223356	USGS/T/ISC
1978202	7/21/78	2:20:12.400	38.73	39.28	-9	-9.0	-1	0	u	223388	USGS/T/ISC/RL
1978212	7/31/78	16:37:14.840	40.37	52.91	33	4.3	32	7	u	223981	USGS/T/ISC
1978225	8/13/78	17:20:25.130	39.33	41.07	128	4.3	26	10	u	224521	USGS/T/ISC
1978227	8/15/78	9:04:22.470	41.25	43.99	8	4.7	108	11	u	224602	USGS/T/ISC
1978232	8/20/78	2:30:03.440	42.29	49.98	33	4.0	7	6	u	224802	USGS/T/ISC
1978234	8/22/78	22:48:10.620	41.94	43.87	4	4.8	151	15	u	224943	USGS/T/ISC
1978238	8/26/78	13:10:17.580	36.90	54.33	33	-9.0	9	13	u	225106	USGS/T/ISC
1978241	8/29/78	0:19:17.390	41.23	49.53	0	4.4	9	8	u	225194	USGS/T/ISC
1978246	9/03/78	0:21:16.700	44.45	38.01	33	5.7	364	8	u	225435	USGS/T/ISC
1978246	9/03/78	2:19:26.130	44.45	38.04	0	3.3	7	0	u	225438	USGS/T/ISC
1978250	9/07/78	9:19:52.330	38.06	58.57	33	-9.0	11	16	u	225670	USGS/T/ISC
1978264	9/21/78	11:08:49.200	38.06	38.65	31	4.6	95	18	u	226282	USGS/T/ISC
1978289	10/16/78	13:26:25.600	39.23	37.79	-9	-9.0	-1	0	u	227408	USGS/T/ISC/RL
1978290	10/17/78	16:45:13.780	39.67	41.73	33	-9.0	5	6	u	227457	USGS/T/ISC
1978307	11/03/78	18:54:06.910	42.50	45.26	33	4.4	46	9	u	228167	USGS/T/ISC
1978308	11/04/78	15:22:19.540	37.71	48.95	37	6.0	418	4	u	228205	USGS/T/ISC
1978315	11/11/78	2:45:55.770	38.10	38.44	40	4.1	37	0	u	228513	USGS/T/ISC
1978315	11/11/78	2:47:36.930	37.44	38.11	33	4.5	28	0	u	228514	USGS/T/ISC
1978320	11/16/78	5:46:09.480	43.50	46.62	33	3.9	10	5	u	228720	USGS/T/ISC
1978323	11/19/78	16:11:48.530	36.44	36.37	33	-9.0	6	0	u	228873	USGS/T/ISC
1978327	11/23/78	15:24:39.050	44.17	39.34	25	4.4	106	4	u	229059	USGS/T/ISC
1978329	11/25/78	8:57:25.050	39.90	44.07	10	4.4	41	8	u	229142	USGS/T/ISC
1978338	12/04/78	3:12:37.650	38.07	37.43	37	5.0	220	7	u	229684	USGS/T/ISC
1978348	12/14/78	5:08:22.610	45.49	37.36	10	4.7	48	3	u	230194	USGS/T/ISC
1978352	12/18/78	7:59:56.340	47.78	48.14	33	5.9	346	4	nu	230364	USGS/T/ISC
1979001	1/01/79	4:25:39.430	37.64	50.18	33	4.0	6	3	u	231004	USGS/T/ISC
1979132	5/12/79	16:19:54.680	41.42	48.16	33	4.2	8	3	u	237333	USGS/T/ISC
1979157	6/06/79	17:30:56.220	42.39	46.32	70	4.0	40	13	u	238668	USGS/T/ISC
1979159	6/08/79	17:46:10.270	37.07	55.62	3	4.4	54	6	u	238769	USGS/T/ISC
1979166	6/15/79	21:15:04.090	36.12	54.52	33	-9.0	7	6	u	239171	USGS/T/ISC
1979212	7/31/79	5:49:33.650	38.72	38.75	10	4.1	15	0	u	241486	USGS/T/ISC
1979232	8/20/79	22:42:09.810	40.73	52.02	68	4.3	37	6	u	242544	USGS/T/ISC

GTDB: ILPA/MAIO Dataset: Region 3

origin time			lat	lon	dep	mb	ndef	nass	etype	evid	author
1978200	7/19/78	16:08:33.710	34.24	26.12	46	4.7	97	8	u	223326	USGS/T/ISC
1978210	7/29/78	14:53:47.190	38.22	31.55	10	-9.0	11	3	u	223899	USGS/T/ISC
1978214	8/02/78	12:13:12.900	40.59	30.91	-9	-9.0	-1	0	u	224074	USGS/T/ISC/RL
1978218	8/06/78	20:49:40.500	40.57	30.84	-9	-9.0	-1	0	u	224260	USGS/T/ISC/RL
1978222	8/10/78	5:52:20.990	39.02	29.72	24	-9.0	19	3	u	224398	USGS/T/ISC
1978223	8/11/78	15:25:46.810	35.08	31.01	10	-9.0	10	5	u	224450	USGS/T/ISC
1978226	8/14/78	1:37:57.900	40.35	33.80	10	-9.0	16	0	u	224542	USGS/T/ISC
1978234	8/22/78	9:29:32.900	36.39	27.67	105	3.9	42	5	u	224916	USGS/T/ISC
1978237	8/25/78	12:02:08.710	34.07	25.21	10	4.4	147	11	u	225061	USGS/T/ISC
1978238	8/26/78	2:01:04.450	35.60	31.24	10	-9.0	8	1	u	225083	USGS/T/ISC
1978238	8/26/78	3:40:43.140	41.20	33.37	0	-9.0	11	1	u	225087	USGS/T/ISC
1978244	9/01/78	23:07:35.000	36.41	31.01	-9	-9.0	-1	0	u	225385	USGS/T/ISC/RL
1978264	9/21/78	13:58:46.470	38.34	30.71	1	-9.0	8	4	u	226284	USGS/T/ISC

1978274	10/01/78	14:04:53.080	37.35	30.92	8	-9.0	9	0	u	226715	USGS/T/ISC
1978275	10/02/78	20:28:52.390	45.72	26.54	161	4.9	238	13	u	226766	USGS/T/ISC
1978281	10/08/78	8:53:49.680	41.28	32.53	0	-9.0	6	0	u	227061	USGS/T/ISC
1978287	10/14/78	8:37:44.380	40.33	32.74	0	-9.0	4	0	u	227318	USGS/T/ISC
1978291	10/18/78	23:37:05.410	34.96	25.97	10	4.5	116	7	u	227506	USGS/T/ISC
1978295	10/22/78	13:40:21.080	41.81	33.69	0	-9.0	6	0	u	227655	USGS/T/ISC
1978296	10/23/78	22:01:51.260	37.20	31.46	10	-9.0	10	0	u	227692	USGS/T/ISC
1978307	11/03/78	9:35:03.430	40.91	32.34	10	-9.0	19	3	u	228149	USGS/T/ISC
1978328	11/24/78	16:06:01.910	38.64	32.42	10	-9.0	9	0	u	229108	USGS/T/ISC
1978329	11/25/78	13:06:32.520	38.76	31.41	10	-9.0	9	0	u	229148	USGS/T/ISC
1978329	11/25/78	21:02:30.600	38.67	31.23	-9	-9.0	-1	0	u	229164	USGS/T/ISC/RL
1978340	12/06/78	13:09:17.720	40.50	34.97	17	4.6	118	6	u	229789	USGS/T/ISC
1978341	12/07/78	1:05:33.410	35.56	31.40	33	-9.0	6	0	u	229828	USGS/T/ISC
1978347	12/13/78	16:37:27.340	38.28	31.12	0	-9.0	4	0	u	230175	USGS/T/ISC
1979131	5/11/79	1:46:26.780	40.74	23.27	5	4.7	179	5	u	237242	USGS/T/ISC
1979132	5/12/79	7:35:08.250	38.83	31.48	10	-9.0	11	0	u	237314	USGS/T/ISC
1979132	5/12/79	17:52:40.810	38.23	25.94	2	4.4	90	6	u	237338	USGS/T/ISC
1979135	5/15/79	6:59:22.580	34.58	24.45	43	5.5	392	8	u	237462	USGS/T/ISC
1979142	5/22/79	11:50:10.620	34.87	22.15	37	4.5	114	12	u	237829	USGS/T/ISC
1979146	5/26/79	15:58:46.800	41.15	33.57	10	-9.0	15	4	u	238048	USGS/T/ISC
1979148	5/28/79	9:27:33.910	36.45	31.72	111	5.8	448	14	u	238159	USGS/T/ISC
1979149	5/29/79	14:23:08.550	40.89	33.58	10	4.1	16	7	u	238203	USGS/T/ISC
1979152	6/01/79	21:03:34.390	39.22	20.50	47	4.6	112	9	u	238384	USGS/T/ISC
1979166	6/15/79	11:34:16.660	34.94	24.21	41	5.5	310	11	u	239139	USGS/T/ISC
1979167	6/16/79	18:41:59.400	38.72	26.64	12	4.9	254	8	u	239230	USGS/T/ISC
1979177	6/26/79	22:01:06.990	36.80	31.85	0	-9.0	4	0	u	239833	USGS/T/ISC
1979177	6/26/79	22:29:20.390	40.70	30.80	10	-9.0	9	0	u	239834	USGS/T/ISC
1979179	6/28/79	21:22:09.410	40.78	31.85	33	4.7	133	0	u	239929	USGS/T/ISC
1979212	7/31/79	14:13:37.120	41.00	31.09	0	-9.0	7	0	u	241503	USGS/T/ISC
1979214	8/02/79	23:41:14.970	35.63	31.23	33	3.9	16	0	u	241610	USGS/T/ISC
1979223	8/11/79	20:19:11.380	35.61	31.22	80	-9.0	15	1	u	242069	USGS/T/ISC
1979223	8/11/79	22:27:51.820	38.68	31.36	0	-9.0	13	0	u	242076	USGS/T/ISC
1979224	8/12/79	1:16:50.500	36.62	31.29	-9	-9.0	-1	0	u	242082	USGS/T/ISC/RL
1979226	8/14/79	17:32:45.490	33.59	34.56	10	4.3	47	13	u	242237	USGS/T/ISC
1979237	8/25/79	4:29:50.270	39.54	32.24	10	-9.0	12	0	u	242736	USGS/T/ISC

GTDB: ILPA/MAIO Dataset: Region 4

origin time			lat	lon	dep	mb	ndef	nass	etype	evid	author
1978205	7/24/78	15:59:51.370	33.08	48.71	55	4.6	60	17	u	223620	USGS/T/ISC
1978208	7/27/78	6:58:02.400	29.97	50.81	33	4.3	10	14	u	223771	USGS/T/ISC
1978209	7/28/78	2:42:36.820	31.25	49.80	54	4.3	70	20	u	223816	USGS/T/ISC
1978209	7/28/78	19:32:45.640	32.03	49.40	43	4.1	23	15	u	223844	USGS/T/ISC
1978209	7/28/78	21:48:12.490	29.79	52.18	21	4.1	18	16	u	223848	USGS/T/ISC
1978221	8/09/78	19:32:21.920	29.61	52.30	23	4.1	16	21	u	224378	USGS/T/ISC
1978222	8/10/78	19:50:26.540	34.20	47.92	47	4.2	23	13	u	224417	USGS/T/ISC
1978223	8/11/78	17:24:26.400	31.77	50.99	72	4.3	10	16	u	224452	USGS/T/ISC
1978238	8/26/78	16:23:39.740	29.82	51.77	55	4.6	14	13	u	225112	USGS/T/ISC
1978240	8/28/78	0:07:03.580	32.62	49.77	44	5.2	212	13	u	225167	USGS/T/ISC
1978241	8/29/78	14:11:05.670	29.66	51.59	40	4.9	160	24	u	225219	USGS/T/ISC
1978243	8/31/78	20:24:04.530	29.41	51.53	34	4.5	73	17	u	225324	USGS/T/ISC
1978251	9/08/78	12:12:01.570	29.02	51.44	33	4.1	11	10	u	225713	USGS/T/ISC
1978257	9/14/78	14:42:29.880	32.19	49.34	33	4.4	17	6	u	225976	USGS/T/ISC

1978258	9/15/78	11:11:24.860	33.15	46.23	33	-9.0	9	18	u	226015	USGS/T/ISC
1978263	9/20/78	7:55:08.710	31.09	49.36	33	4.5	22	14	u	226233	USGS/T/ISC
1978282	10/09/78	16:25:04.300	32.53	49.95	48	4.7	80	12	u	227123	USGS/T/ISC
1978290	10/17/78	22:04:05.630	30.75	52.14	29	-9.0	5	11	u	227469	USGS/T/ISC
1978334	11/30/78	14:05:08.890	34.34	47.93	33	-9.0	4	8	u	229421	USGS/T/ISC
1978334	11/30/78	20:59:34.710	30.58	50.70	33	4.4	8	10	u	229436	USGS/T/ISC
1978348	12/14/78	7:05:21.790	32.14	49.64	40	5.6	318	4	u	230196	USGS/T/ISC
1978348	12/14/78	7:54:45.250	32.02	49.55	46	5.1	17	7	u	230200	USGS/T/ISC
1978348	12/14/78	12:52:08.030	32.69	50.19	0	4.3	4	3	u	230212	USGS/T/ISC
1978348	12/14/78	15:42:54.320	32.14	49.54	46	4.7	45	9	u	230217	USGS/T/ISC
1978354	12/20/78	14:56:44.570	32.45	49.69	33	3.6	8	8	u	230466	USGS/T/ISC
1978356	12/22/78	23:26:05.110	32.45	49.48	33	4.4	4	5	u	230558	USGS/T/ISC
1978359	12/25/78	11:08:43.010	32.27	50.01	33	4.3	9	3	u	230692	USGS/T/ISC
1978362	12/28/78	22:45:00.480	32.10	49.64	47	4.4	10	3	u	230882	USGS/T/ISC
1979135	5/15/79	0:29:06.560	28.43	51.36	33	4.4	8	3	u	237452	USGS/T/ISC
1979136	5/16/79	22:20:25.060	32.64	47.77	33	4.4	13	9	u	237543	USGS/T/ISC
1979146	5/26/79	7:03:56.170	29.73	50.34	47	4.3	25	6	u	238035	USGS/T/ISC
1979153	6/02/79	1:34:34.320	32.62	49.70	38	4.6	12	4	u	238399	USGS/T/ISC
1979177	6/26/79	15:54:15.020	30.86	49.57	33	4.3	17	0	u	239821	USGS/T/ISC
1979177	6/26/79	16:14:28.260	30.69	49.88	33	4.5	12	0	u	239822	USGS/T/ISC
1979182	7/01/79	9:37:31.770	34.83	46.17	50	4.7	106	0	u	240053	USGS/T/ISC
1979227	8/15/79	23:10:05.210	30.50	50.66	33	4.3	10	13	u	242294	USGS/T/ISC
1979231	8/19/79	12:14:01.810	31.24	50.21	86	4.4	10	12	u	242489	USGS/T/ISC
1979231	8/19/79	12:23:18.470	30.40	50.98	54	4.8	86	17	u	242490	USGS/T/ISC
1979267	9/24/79	20:33:02.000	31.66	51.60	33	4.0	7	12	u	244251	USGS/T/ISC

GTDB: ILPA/MAIO Dataset: Region 5

origin time			lat	lon	dep	mb	ndef	nass	etype	evid	author
1978208	7/27/78	19:41:16.780	32.49	56.13	33	-9.0	6	13	u	223801	USGS/T/ISC
1978217	8/05/78	4:01:38.230	33.22	59.63	33	-9.0	6	15	u	224194	USGS/T/ISC
1978218	8/06/78	23:21:44.300	32.80	56.39	33	-9.0	9	20	u	224263	USGS/T/ISC
1978260	9/17/78	12:43:21.730	34.19	57.50	2	4.7	65	15	u	226103	USGS/T/ISC
1978260	9/17/78	14:22:16.800	33.62	56.96	33	4.5	21	19	u	226106	USGS/T/ISC
1978260	9/17/78	15:54:39.180	34.87	57.48	33	-9.0	9	23	u	226115	USGS/T/ISC
1978260	9/17/78	21:39:46.260	33.80	57.10	33	4.6	17	12	u	226127	USGS/T/ISC
1978261	9/18/78	1:34:49.060	33.80	57.28	33	4.4	21	21	u	226129	USGS/T/ISC
1978261	9/18/78	3:26:10.760	34.32	56.70	33	4.1	22	19	u	226134	USGS/T/ISC
1978261	9/18/78	4:50:04.070	33.57	57.47	33	4.7	55	11	u	226140	USGS/T/ISC
1978261	9/18/78	4:54:28.130	34.00	57.53	33	4.6	13	14	u	226141	USGS/T/ISC
1978263	9/20/78	4:45:59.650	33.25	56.67	50	4.1	44	16	u	226227	USGS/T/ISC
1978267	9/24/78	3:05:32.300	33.84	56.93	33	-9.0	11	15	u	226396	USGS/T/ISC
1978270	9/27/78	18:48:52.500	33.35	57.35	33	4.2	5	16	u	226559	USGS/T/ISC
1978274	10/01/78	10:49:47.500	33.42	57.25	13	4.3	10	12	eq	226707	Berberian
1978274	10/01/78	14:09:35.110	34.82	56.71	33	-9.0	5	10	u	226716	USGS/T/ISC
1978282	10/09/78	16:04:38.200	33.34	57.28	8	4.6	46	15	eq	227122	Berberian
1978285	10/12/78	15:01:39.420	33.36	57.33	8	4.9	77	14	eq	227252	Berberian
1978287	10/14/78	13:36:11.820	33.53	56.98	45	-9.0	8	11	u	227326	USGS/T/ISC
1978292	10/19/78	14:39:56.090	33.52	57.11	12	-9.0	5	8	eq	227527	Berberian
1978301	10/28/78	9:02:45.920	33.83	58.24	33	-9.0	6	8	u	227881	USGS/T/ISC
1978304	10/31/78	8:07:56.920	33.49	58.81	33	-9.0	5	8	u	228001	USGS/T/ISC
1978305	11/01/78	22:53:11.550	33.60	57.28	33	-9.0	5	4	u	228069	USGS/T/ISC
1978306	11/02/78	4:16:56.820	31.32	56.33	33	4.1	15	29	u	228088	USGS/T/ISC

1978308	11/04/78	9:08:56.780	33.62	57.48	33	4.0	10	16	u	228195	USGS/T/ISC
1978308	11/04/78	17:12:27.000	33.53	57.11	40	4.4	28	14	u	228212	USGS/T/ISC
1978308	11/04/78	19:30:11.450	33.85	57.62	33	-9.0	5	9	u	228214	USGS/T/ISC
1978310	11/06/78	16:49:54.150	33.38	57.47	7	4.5	60	8	u	228313	USGS/T/ISC
1978310	11/06/78	23:14:09.330	33.58	57.08	34	4.5	10	11	u	228325	USGS/T/ISC
1978310	11/06/78	23:46:43.240	33.16	54.97	46	4.6	93	12	u	228326	USGS/T/ISC
1978325	11/21/78	5:02:00.900	33.73	57.04	33	-9.0	8	8	u	228938	USGS/T/ISC
1978327	11/23/78	12:48:42.190	33.69	57.07	55	4.2	20	6	u	229051	USGS/T/ISC
1978327	11/23/78	14:37:29.730	33.73	57.13	45	4.6	10	5	u	229056	USGS/T/ISC
1978327	11/23/78	23:07:57.890	32.47	56.06	33	-9.0	8	8	u	229075	USGS/T/ISC
1978336	12/02/78	0:44:39.900	33.57	58.38	33	-9.0	6	4	u	229527	USGS/T/ISC
1978337	12/03/78	23:16:48.130	33.99	57.61	33	-9.0	7	4	u	229669	USGS/T/ISC
1978340	12/06/78	17:18:12.860	33.29	57.15	19	5.3	184	7	u	229811	USGS/T/ISC
1978340	12/06/78	20:38:09.160	33.16	57.12	33	4.7	73	9	u	229819	USGS/T/ISC
1978346	12/12/78	19:46:52.450	33.77	57.99	33	-9.0	6	6	u	230139	USGS/T/ISC
1978359	12/25/78	8:52:12.380	33.80	57.59	33	-9.0	6	3	u	230687	USGS/T/ISC
1978360	12/26/78	10:35:23.430	33.63	57.24	40	4.4	10	3	u	230756	USGS/T/ISC
1979092	4/02/79	22:03:47.750	33.86	59.36	33	3.8	9	9	u	235364	USGS/T/ISC
1979095	4/05/79	3:45:37.330	33.67	57.22	33	4.6	20	12	u	235440	USGS/T/ISC
1979135	5/15/79	21:56:38.330	33.52	57.15	33	-9.0	9	10	u	237483	USGS/T/ISC
1979135	5/15/79	22:03:49.600	33.47	57.04	33	-9.0	8	8	u	237484	USGS/T/ISC
1979143	5/23/79	12:19:49.220	31.98	54.62	33	-9.0	7	9	u	237887	USGS/T/ISC
1979147	5/27/79	6:43:15.870	33.23	57.24	11	4.6	91	14	u	238094	USGS/T/ISC
1979153	6/02/79	17:57:30.850	33.80	57.02	3	4.3	19	9	u	238446	USGS/T/ISC
1979154	6/03/79	12:19:08.990	34.01	57.07	40	4.4	30	10	u	238484	USGS/T/ISC
1979176	6/25/79	20:04:59.340	34.02	57.55	33	-9.0	6	0	u	239779	USGS/T/ISC
1979186	7/05/79	4:46:10.020	33.69	57.17	9	4.5	83	12	u	240256	USGS/T/ISC
1979229	8/17/79	18:45:39.800	33.47	56.93	33	4.3	34	14	u	242398	USGS/T/ISC
1979237	8/25/79	13:46:25.220	33.51	58.94	15	4.1	10	13	u	242749	USGS/T/ISC

GTDB: ILPA/MAIO Dataset: Region 6

origin time			lat	lon	dep	mb	ndef	nass	etype	evid	author
1978341	12/07/78	16:22:02.730	12.91	49.75	10	4.3	10	6	u	229872	USGS/T/ISC
1978343	12/09/78	7:12:52.170	24.00	26.39	33	5.2	205	8	u	229960	USGS/T/ISC
1978355	12/21/78	4:03:53.960	11.54	42.96	16	5.1	145	4	u	230492	USGS/T/ISC
1979133	5/13/79	20:48:00.580	18.81	39.32	10	4.8	68	3	u	237393	USGS/T/ISC
1979133	5/13/79	20:55:48.050	19.62	39.15	33	4.5	33	2	u	237394	USGS/T/ISC
1979145	5/25/79	17:10:58.690	25.16	36.52	33	4.6	51	5	u	238003	USGS/T/ISC
1979198	7/17/79	17:07:04.530	17.66	40.13	51	5.1	84	13	u	240796	USGS/T/ISC
1979203	7/22/79	18:51:57.940	17.40	39.96	33	4.1	18	13	u	241069	USGS/T/ISC

GTDB: ILPA/MAIO Dataset: Region 7

origin time			lat	lon	dep	mb	ndef	nass	etype	evid	author
1978209	7/28/78	14:34:55.770	29.90	60.37	25	4.1	10	9	u	223834	USGS/T/ISC
1978210	7/29/78	8:08:38.910	27.51	56.23	29	4.3	23	1	u	223879	USGS/T/ISC
1978214	8/02/78	6:54:30.730	27.33	55.89	46	4.5	55	12	u	224062	USGS/T/ISC
1978223	8/11/78	13:59:10.930	26.86	53.62	88	4.0	7	7	u	224449	USGS/T/ISC
1978239	8/27/78	20:18:08.600	27.24	56.04	48	4.3	37	16	u	225158	USGS/T/ISC
1978249	9/06/78	13:00:56.540	28.54	56.98	33	4.6	57	2	u	225641	USGS/T/ISC
1978252	9/09/78	22:38:02.430	26.94	56.59	33	4.3	33	12	u	225783	USGS/T/ISC

1978252	9/09/78	22:44:41.290	26.63	56.93	33	4.2	8	9	u	225784	USGS/T/ISC
1979095	4/05/79	4:05:12.220	26.51	60.98	3	4.7	130	9	u	235443	USGS/T/ISC
1979095	4/05/79	4:48:22.940	26.43	60.96	33	4.3	21	9	u	235445	USGS/T/ISC
1979133	5/13/79	20:12:54.750	26.19	60.95	10	4.5	45	0	u	237392	USGS/T/ISC
1979134	5/14/79	0:56:31.080	26.41	61.37	57	4.4	33	3	u	237407	USGS/T/ISC
1979137	5/17/79	6:16:19.370	25.66	61.02	33	3.8	4	7	u	237560	USGS/T/ISC
1979141	5/21/79	8:06:48.070	26.36	61.06	33	4.5	17	11	u	237760	USGS/T/ISC
1979148	5/28/79	15:12:43.200	26.88	55.95	42	4.7	10	6	u	238172	USGS/T/ISC
1979152	6/01/79	23:38:42.570	27.66	55.04	55	4.4	23	8	u	238392	USGS/T/ISC
1979165	6/14/79	20:53:56.670	26.66	54.92	33	4.5	10	6	u	239085	USGS/T/ISC
1979196	7/15/79	1:56:17.130	26.75	55.81	0	4.1	9	10	u	240681	USGS/T/ISC
1979208	7/27/79	20:46:51.450	29.59	55.84	33	3.7	5	1	u	241315	USGS/T/ISC

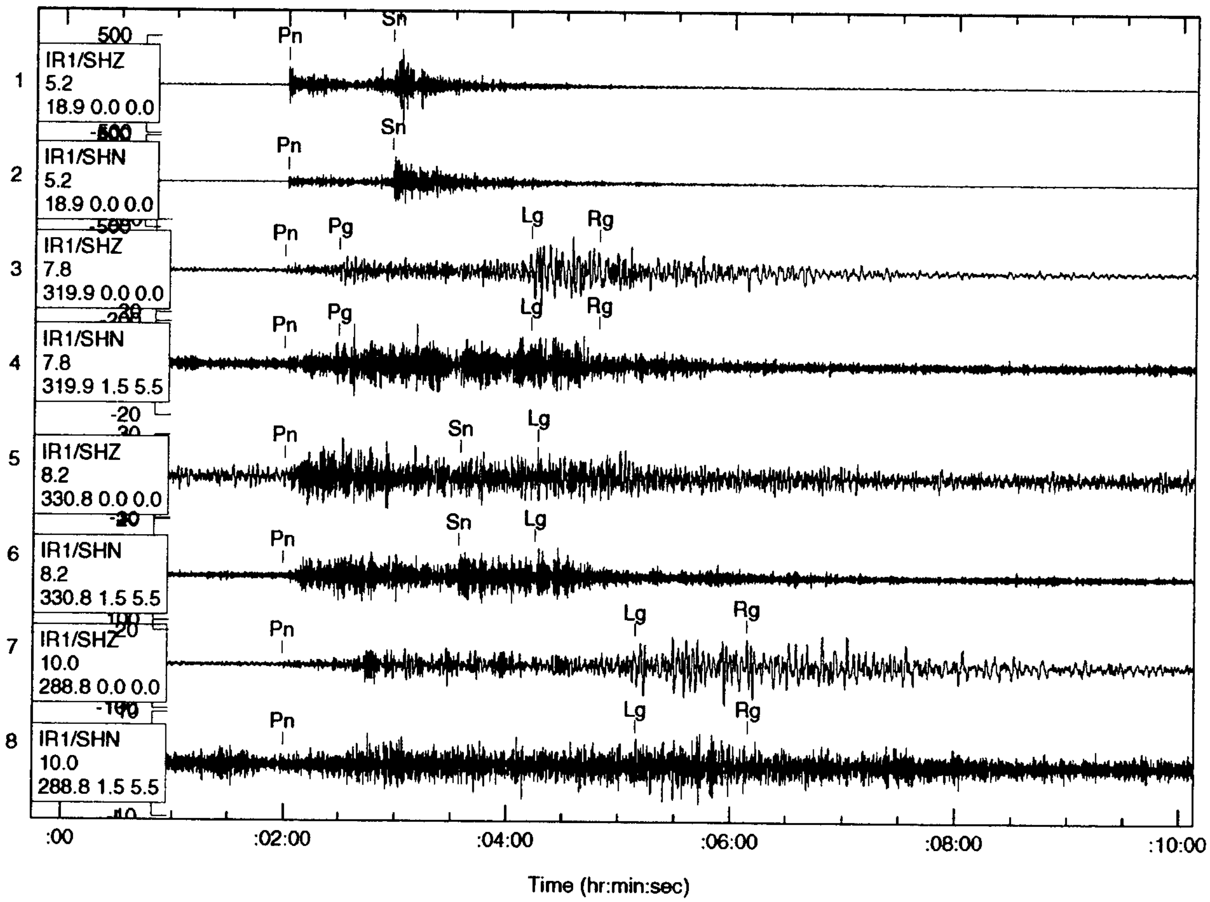
GTDB: ILPA/MAIO Dataset: Region 8

origin time			lat	lon	dep	mb	ndef	nass	etype	evid	author
1978200	7/19/78	15:05:25.110	32.80	67.83	33	-9.0	5	0	u	223321	USGS/T/ISC
1978218	8/06/78	21:09:41.000	29.20	69.30	33	-9.0	-1	0	u	224261	USGS/T/ISC/RL
1978273	9/30/78	17:24:16.900	33.23	69.82	33	-9.0	5	0	u	226684	USGS/T/ISC
1978273	9/30/78	17:30:55.860	33.77	69.30	38	-9.0	9	0	u	226685	USGS/T/ISC
1978286	10/13/78	15:06:41.930	32.46	68.34	33	-9.0	5	0	u	227293	USGS/T/ISC
1978289	10/16/78	15:47:51.190	29.90	67.89	0	4.4	13	7	u	227409	USGS/T/ISC
1978313	11/09/78	13:24:28.940	30.46	66.82	33	-9.0	6	0	u	228456	USGS/T/ISC
1978313	11/09/78	19:18:44.410	29.79	66.15	33	-9.0	7	0	u	228462	USGS/T/ISC
1978338	12/04/78	0:18:51.630	30.39	66.35	30	4.3	11	6	u	229675	USGS/T/ISC
1978343	12/09/78	1:30:03.960	28.84	65.17	33	-9.0	8	0	u	229949	USGS/T/ISC
1978344	12/10/78	1:30:16.300	28.57	66.59	33	4.8	104	8	u	230000	USGS/T/ISC
1978344	12/10/78	2:26:57.760	28.50	66.43	33	4.6	17	0	u	230003	USGS/T/ISC
1978347	12/13/78	13:30:42.100	29.49	67.47	33	-9.0	4	0	u	230170	USGS/T/ISC
1978354	12/20/78	6:00:35.630	28.75	66.58	33	4.2	13	3	u	230445	USGS/T/ISC
1978365	12/31/78	18:45:03.930	28.60	66.63	33	4.3	9	3	u	230985	USGS/T/ISC
1979004	1/04/79	13:37:27.870	30.80	68.32	33	4.0	4	0	u	231185	USGS/T/ISC
1979174	6/23/79	9:42:11.550	32.92	69.67	33	-9.0	4	3	u	239651	USGS/T/ISC
1979175	6/24/79	13:49:03.780	30.31	66.54	38	4.7	71	0	u	239719	USGS/T/ISC
1979221	8/09/79	20:02:38.620	26.54	67.43	33	4.1	6	4	u	241969	USGS/T/ISC
1979224	8/12/79	1:25:18.030	23.71	65.16	33	4.6	46	8	u	242083	USGS/T/ISC
1979239	8/27/79	1:04:12.710	26.32	68.03	33	4.7	15	8	u	242818	USGS/T/ISC

Sample Waveform Plots

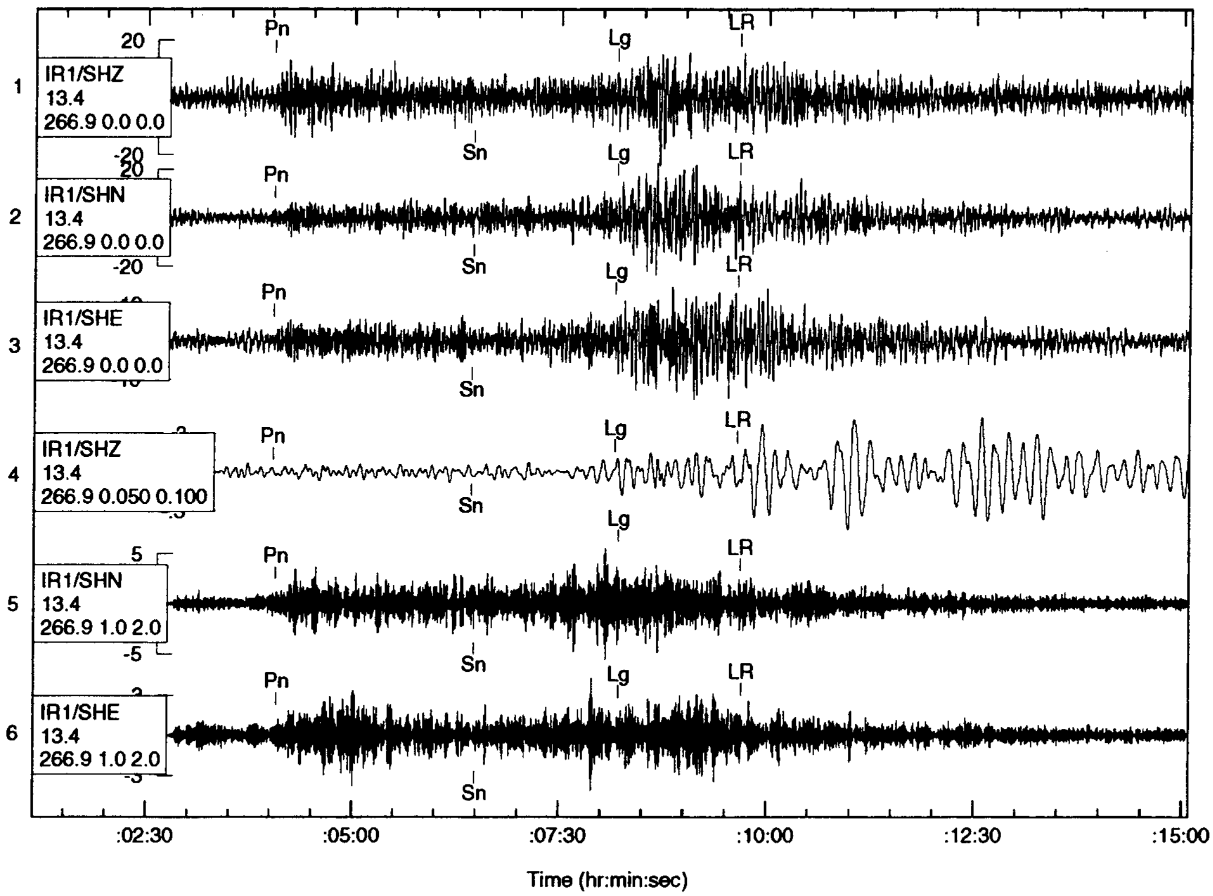
The figures in this section show sample recordings of Sn and Lg phases at regional distances to ILPA and MAIO. Regions 1 and 8 record mostly teleseismic phases, P and S, and are not shown as examples.

Additional observations resulting from interactive waveform analysis, are shown in the sample plots in the ILPA/MAIO Handbook (Grant *et al.*, 1996b).



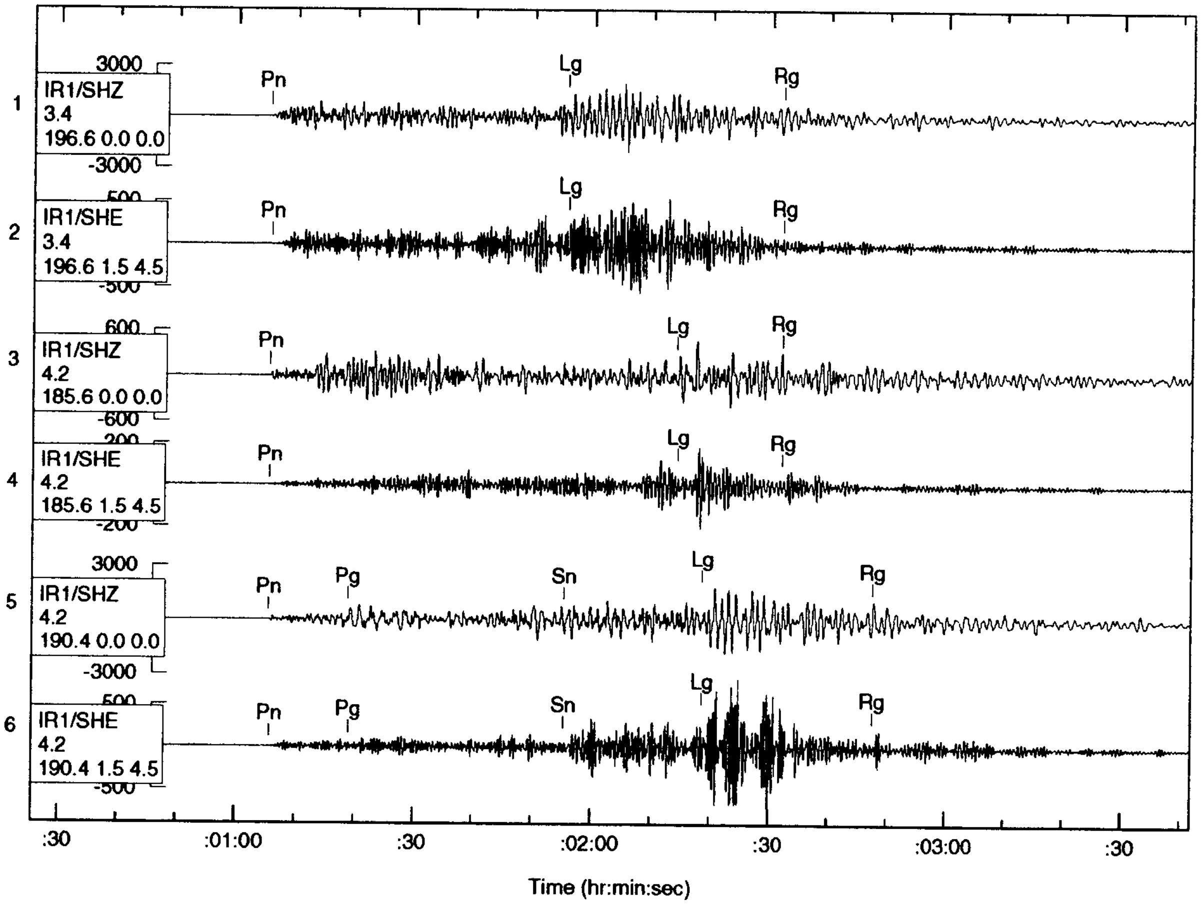
Time scale: two units = one minute.

Figure 11: Region 2 examples. IR1 SHZ and SHN traces are shown for four events. Traces are: 1-2) ev223981-2 (mb 4.3, h 33) good Sn; 3-4) ev224602-2 (mb 4.7, h 8) ambiguous Sn; 5-6) ev228167-2 (mb 4.4, h 33) good Sn; 7-8) ev226282-2 (mb 4.6, h 30) no Sn.



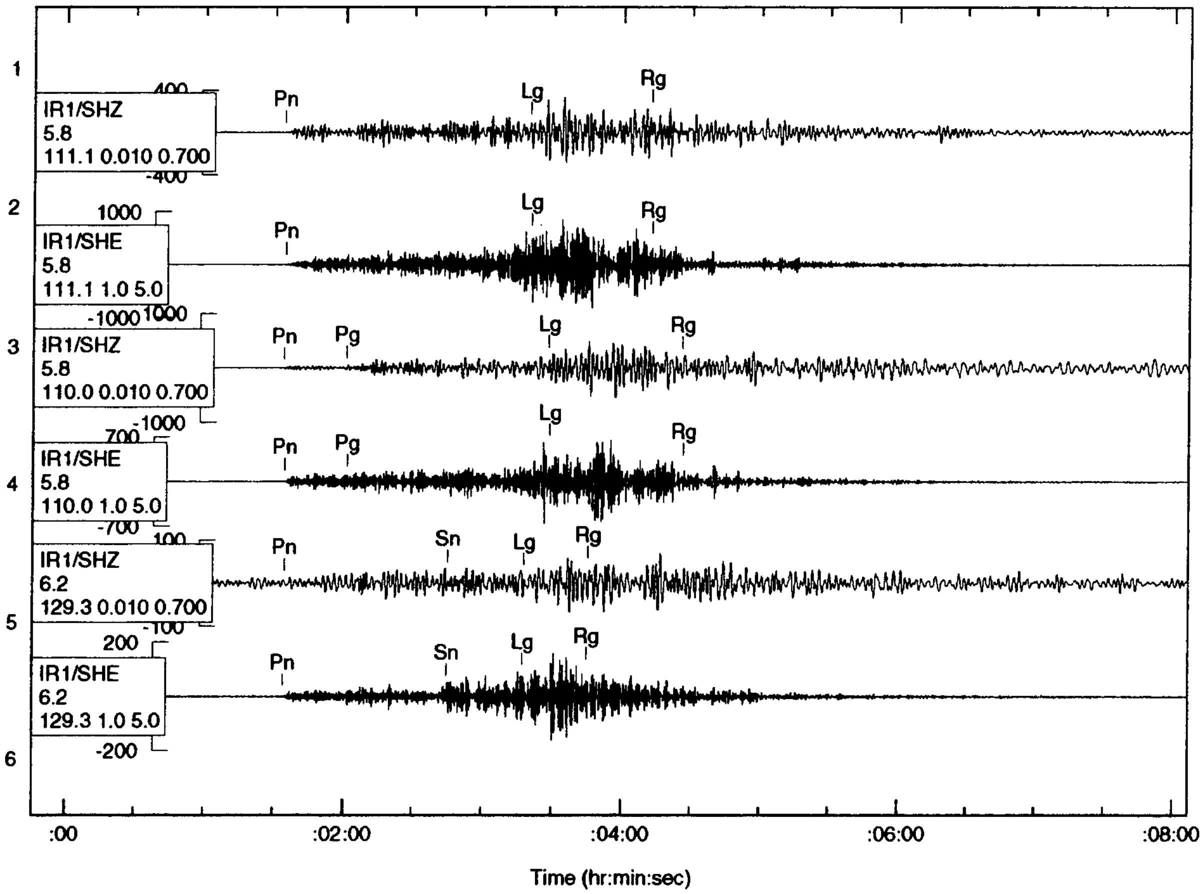
Time scale: two units = one minute.

Figure 12: Region 3 example. Event ev242237-3 (mb 4.3, h 10) with no Sn at predicted time. Predicted arrivals are plotted beneath the waveforms.



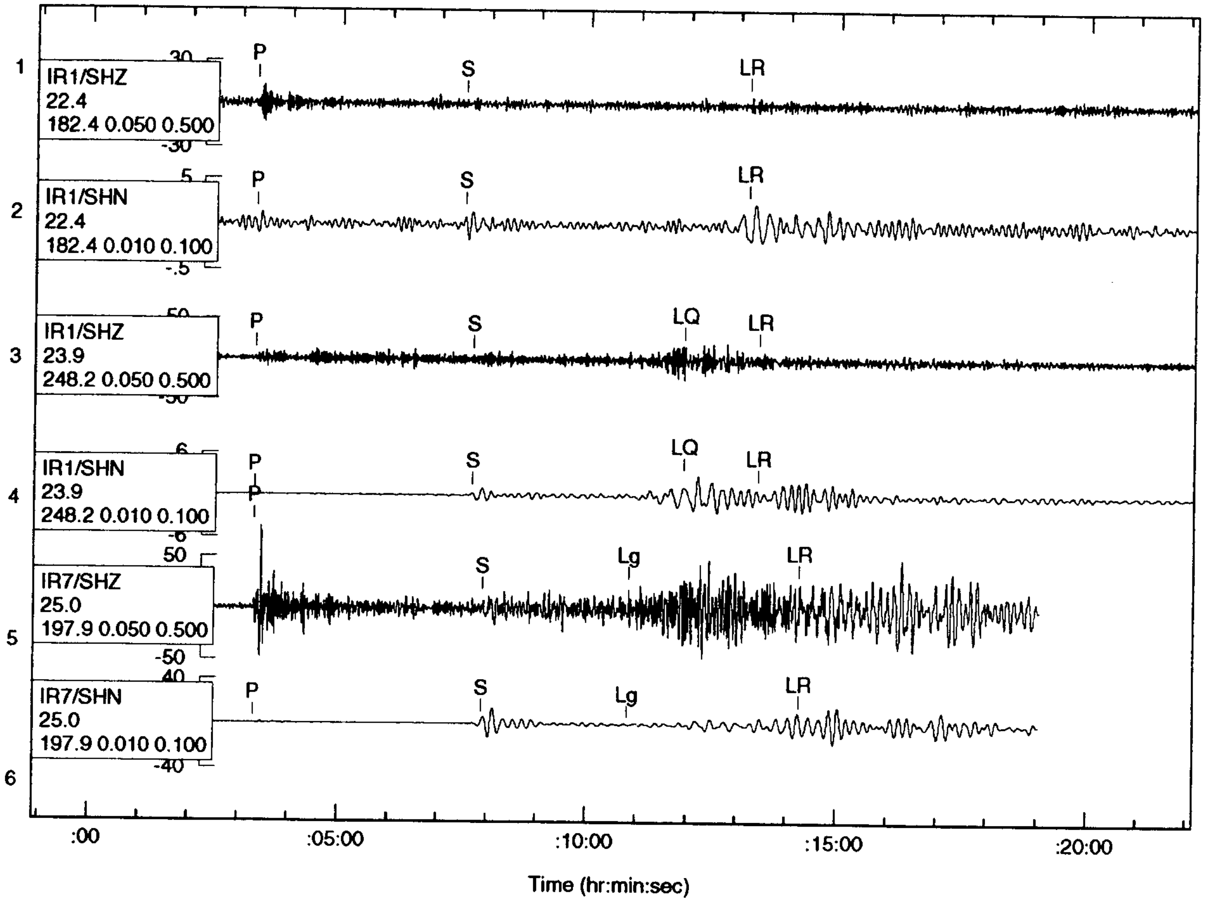
Time scale: six units = one minute.

Figure 13: Region 4 examples. IR1 SHZ and SHE traces are shown for three events. Traces are: 1-2) ev230217-4 (mb 4.7, h 46) poor Sn; 3-4) ev242489-4 (mb 4.4, h 86) no Sn; 5-6) ev223816-4 (mb 4.3, h 54) fair Sn.



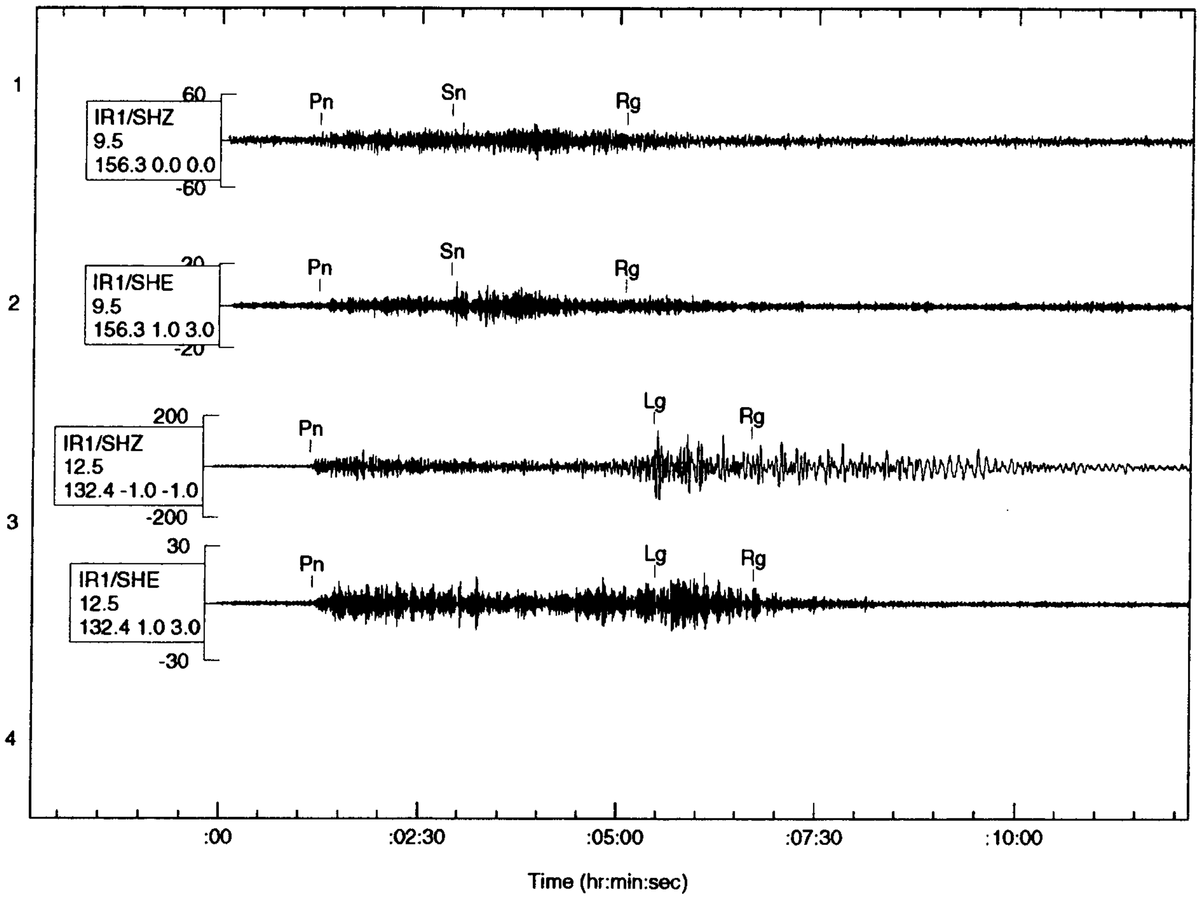
Time scale: two units = one minute.

Figure 14: Region 5 examples. IR1 SHZ and SHE traces are shown for three events: 1-2) ev229819-5 (mb 4.7, h 33) no Sn; 3-4) ev238094-5 (mb 4.6, h 11) questionable Sn; 5-6) ev228088-5 (mb 4.1, h 33) good Sn.



Time scale: one unit = one minute.

Figure 15: Region 6 examples. IR1 SHZ and SHN traces are shown for three events. Traces are: 1-2) ev229872-6 (mb 4.3, h 10) no Lg; 3-4) ev229960-6 (mb 5.2, h 33) questionable Lg; 5-6) ev230492-6 (mb 5.1, h 17) good Lg.



Time scale: two units = one minute.

Figure 16: Region 7 examples. IR1 SHZ and SHE traces are shown for two events: 1-2) ev239085-7 (mb 4.5, h 33) no Lg, good Sn; 3-4) ev235443-7 (mb 4.7, h 3) good Lg, very questionable Sn.

Chapter 3

The Spanish Dataset

The Spanish dataset is based on event locations from the bulletin produced by the Instituto Geografica Nacional (IGN), Spain. Events occurred between May 1993 and July 1995. From the IGN bulletin, we identified 5 clusters of interest, totaling 170 events. Four of these clusters are shown in Figure 17. The fifth cluster is in the Canary Islands.

For these 5 clusters, all available broadband waveforms were retrieved from the IRIS database for the following stations: ANTO, AQU, KEG, MEB, PAB, TBT, TTE, VSL. Data were also retrieved for the Spanish Array, Sonseca (station code ESDC).

About the IGN Bulletin

The seismic bulletin has been produced by IGN since 1986. The network consists of 30 SP vertical sensors, 2 IRIS stations (PAB and TBT), the Sonseca array, and a subnet in the Canary Islands. Both natural and artificial events are included in the bulletin. IGN cooperates with other data centers including 2 in France, 2 in North Africa, and 1 in Portugal. Locations are calculated within 48 hours after an event occurs, updated monthly, and finalized yearly. The monthly bulletins are sent to the CMR as Spain's contribution to the "GAMMA" bulletin of the IDC. We obtained the IGN bulletin from the "GAMMA" database account at CMR.

About the Sonseca Array

The Sonseca array has 20 short-period vertical sensors arranged in a filled circular pattern of about 9 km aperture. The reference element is ESLA, and it records 9 channels: three-component broadband, short-period and long-period. There is also an outer ring of 6 stations recording only long-period data. The Sonseca array did not contribute to the locations of the events in the IGN bulletin before 1996.

About the Five Event Clusters

The two clusters named "Fuente" and "Puerto" consist of quarry blasts. The associated mining areas for the "Fuente" region are Pueblonuevo-Penarrolla and Fuente Obejuna. For the Puerto region, it is Puertollano. Mining regions are represented on the map by circles scaled to 100 km diameter. The two clusters in Morocco, named Alhucemas and Melilla, are presumed earthquakes since each is associated with an aftershock series related to a large, known event.

Interactive Waveform Analysis

This section summarizes some of the observations made by Flori Ryall during analysis of the Spanish dataset. The *assoc* table includes 723 phases timed and identified manually.

Sonseca array data were beamed for each event. However, initial Pn was read on the beam but added to the reference station, ESLA because the beamed trace is not saved.

For most of the clusters in this dataset, surface waves were timed on the rotated horizontal channels. However, since Geotool's rotation program failed whenever start times differed on the three-component segments, the phases were picked on unrotated channels in those instances.

The Alhucemas Region

The Alhucemas region consists of 53 events ranging in magnitude from ML 2.8 to ML 4.6. The distance to PAB and ESDC is about 4.5 degrees. Only PAB and the Sonseca array recorded these events well enough for analysis.

The Melilla Region

The Melilla region, about 100 km east of Alhucemas, consists of 15 events ranging in magnitude from ML 2.6 to ML 4.4. Only PAB, MEB, and ESDC recorded these events well enough for analysis. Distances to PAB and ESDC range from 4.5 to 4.9 degrees, and for MEB, from 4.1 to 4.5 degrees. Of the 9 events with MEB data, only 4 had signals large enough to read, and Lg was not evident at any of them.

The Fuente Region

Of the 47 quarry blasts in the Fuente region, 31 have available waveforms from both PAB and ESDC, and 8 have waveforms at ESDC only. The IGN bulletin magnitudes range from ML 2.5 to ML 2.9. The distance range to ESDC is about 1.7 degrees, and to PAB, about 1.5 degrees.

The initial P arrival was identified as Pg, based on consistent velocity values obtained by frequency-wavenumber (FK) processing of the Sonseca array data using the **geotool** utility. A Pg velocity of 6.6 km/s was obtained from the FK results for a subset of 35 events. Since the distance to PAB was smaller by about 0.2 degrees, the first P arrival was also identified as Pg at that station.

The Puertollano Region

Of the 42 quarry blasts (and 1 presumed mine tremor, qmt) in the Puerto region, 21 have both PAB and ESDC waveforms, and 8 have waveforms at ESDC only. The bulletin magnitudes range from ML 2.5 to ML 2.9. Distance to both PAB and ESDC is between 0.9 and 1.1 degrees. The initial P arrival was identified as Pg, based on consistent velocity values obtained by FK processing. Most of the larger events also recorded a higher-amplitude

arrival (possibly PmP) 0.4s - 0.5s after Pg. An average Pg velocity of 6.6 km/s was obtained by FK processing of 21 events. That velocity is high for Pg; it may reflect a mixture of Pg and PmP in the FK processing. Most Pg arrivals are small and emergent at ESDC. The same characteristic is observed for Sg at PAB.

A couple of anomalies were noted for the phase Rg. First, Rg has opposite particle motion at the two stations: prograde at ESDC and retrogade at PAB. Particle motions for Pg appeared to be correct, eliminating the possibility that the instrument orientations are in error. Second, FK processing of this phase gave a consistently high average apparent velocity of 4.66 km/s for the Rg of a subset of 21 events.

The Canary Islands Region

Of the 11 events in the Canary Islands, 9 had no visible signal for the available data. Two events had signals recorded at station TBT. Only the two events with observed phases are included in the GTDB.

Event Lists

In the event listings that follow, the origin time, latitude, longitude, depth, and mb are defined by the IGN bulletin. The parameter "ndef" represents the number of defining phases used by author (IGN) to define the event. The parameter "nass" is the number of GTDB phases associated with the event.

The event type field, etype, is "eq" (earthquake) for the Melilla, Alhucemas and Canary clusters. Event type is "qb" (quarry blast) for the Puertollano and Fuente clusters. One event from the Puertollano region is labeled "qmt" (quarry or mine tremor) based on personal communication with Carmen Lopez of IGN.

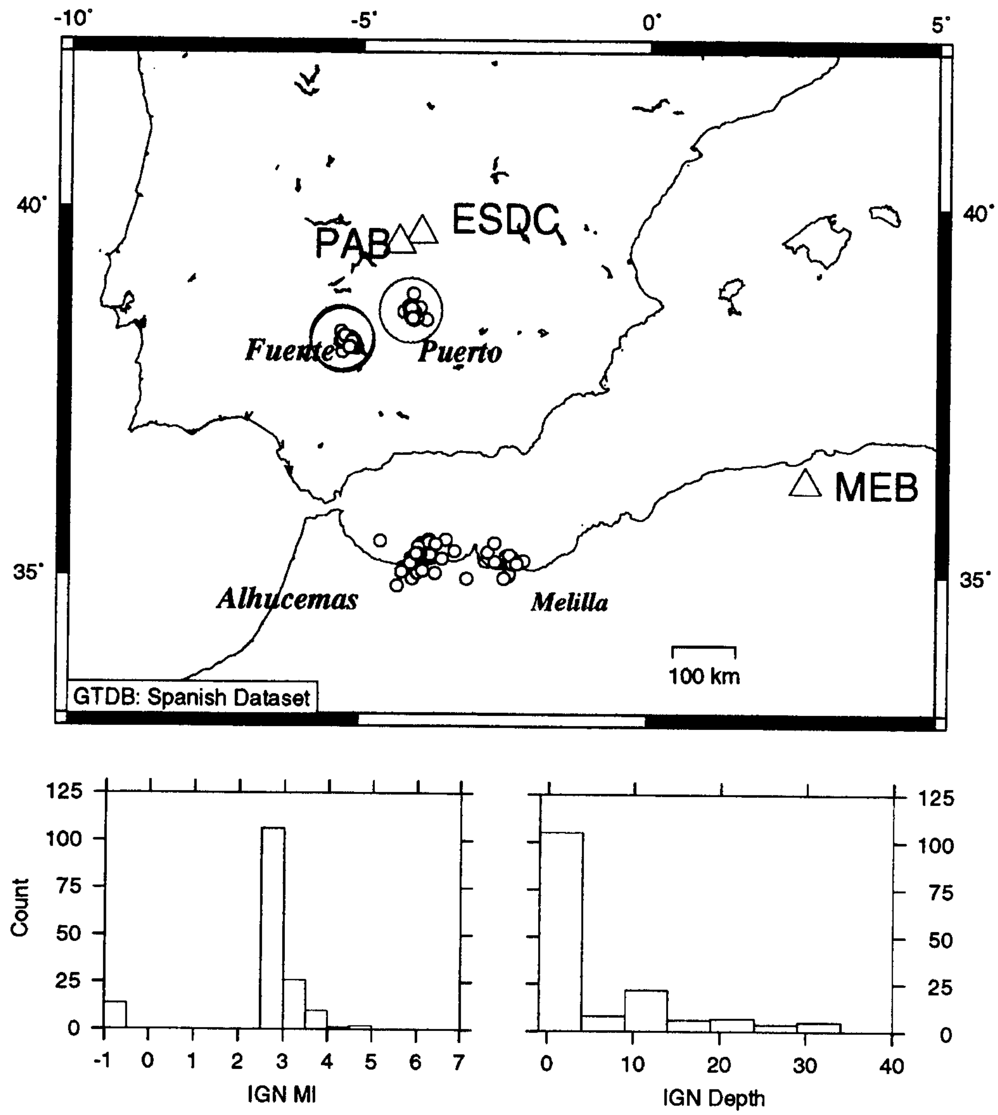


Figure 17: The Spanish Dataset. Most of the 168 events shown are recorded at ESDC and PAB; several on the Mednet station, MEB. All event locations are from the IGN bulletin.

GTDB: Spanish Dataset: Region: Alhucemas

origin time			lat	lon	dep	d	ml	ndef	nass	etype	evid	author
1993232	8/20/1993	21:10:27.000	35.10	-4.21	14	-	-9.0	27	5	eq	1	IGN
1993233	8/21/1993	19:43:17.100	35.05	-4.27	0	-	2.8	17	5	eq	2	IGN
1993276	10/03/1993	21:20:08.800	34.94	-3.13	25	-	2.8	10	4	eq	3	IGN
1993334	11/30/1993	23:23:01.000	35.50	-3.50	58	-	3.0	14	5	eq	4	IGN
1993355	12/21/1993	16:58:04.700	35.44	-3.68	10	-	3.2	13	6	eq	5	IGN
1994008	1/08/1994	4:21:11.000	34.96	-4.29	33	-	-9.0	20	5	eq	6	IGN
1994121	5/01/1994	5:33:35.500	35.40	-3.99	1	-	3.0	36	5	eq	7	IGN
1994121	5/01/1994	6:31:23.000	35.30	-3.99	10	-	-9.0	13	8	eq	8	IGN
1994121	5/01/1994	8:41:28.300	35.31	-4.01	5	-	3.0	32	5	eq	9	IGN
1994123	5/03/1994	14:57:10.200	35.34	-3.34	33	-	3.1	16	5	eq	10	IGN
1994146	5/26/1994	8:26:52.900	35.30	-4.03	0	-	4.5	50	10	eq	11	IGN
1994146	5/26/1994	9:25:20.300	35.09	-4.10	22	-	3.5	2	5	eq	12	IGN
1994146	5/26/1994	9:40:00.600	35.14	-4.14	0	-	3.4	27	4	eq	13	IGN
1994146	5/26/1994	12:27:50.000	34.95	-4.08	10	-	-9.0	19	10	eq	14	IGN
1994146	5/26/1994	13:08:50.300	35.38	-3.97	5	-	2.9	18	5	eq	15	IGN
1994146	5/26/1994	18:06:04.600	35.36	-3.86	14	-	3.0	20	4	eq	16	IGN
1994147	5/27/1994	0:25:44.600	35.24	-3.90	31	-	2.6	12	4	eq	17	IGN
1994148	5/28/1994	3:32:05.300	35.42	-3.84	19	-	3.1	32	5	eq	18	IGN
1994148	5/28/1994	13:26:45.500	35.30	-3.93	12	-	2.8	23	10	eq	19	IGN
1994152	6/01/1994	10:33:51.400	35.39	-3.89	6	-	2.6	12	4	eq	20	IGN
1994152	6/01/1994	17:20:51.400	35.22	-4.03	0	-	2.9	19	6	eq	21	IGN
1994154	6/03/1994	8:57:39.400	35.22	-4.00	13	-	4.6	3	10	eq	22	IGN
1994155	6/04/1994	1:35:37.500	35.36	-3.86	14	-	3.1	26	4	eq	23	IGN
1994157	6/06/1994	0:04:10.500	35.50	-3.80	1	-	2.7	20	4	eq	24	IGN
1994157	6/06/1994	2:06:26.400	35.22	-3.87	27	-	3.0	28	6	eq	25	IGN
1994159	6/08/1994	3:08:30.000	35.03	-4.00	10	-	-9.0	11	6	eq	26	IGN
1994164	6/13/1994	10:19:37.000	35.24	-3.80	10	-	-9.0	7	4	eq	27	IGN
1994166	6/15/1994	0:15:22.100	35.19	-3.95	23	-	3.5	29	9	eq	28	IGN
1994167	6/16/1994	10:20:33.600	35.22	-3.99	12	-	3.8	38	5	eq	29	IGN
1994167	6/16/1994	21:08:48.600	35.25	-3.73	19	-	2.8	19	4	eq	30	IGN
1994173	6/22/1994	21:26:33.000	35.43	-3.93	5	-	2.8	16	4	eq	31	IGN
1994184	7/03/1994	5:53:41.000	35.26	-3.82	31	-	3.2	9	4	eq	32	IGN
1994207	7/26/1994	6:25:01.400	35.35	-3.98	5	-	3.3	30	8	eq	33	IGN
1994208	7/27/1994	19:12:02.000	35.24	-3.94	0	-	3.3	17	4	eq	34	IGN
1994222	8/10/1994	17:41:56.700	35.30	-4.00	0	-	3.6	35	8	eq	35	IGN
1994229	8/17/1994	19:26:10.000	35.27	-4.03	15	-	3.6	35	7	eq	36	IGN
1994232	8/20/1994	4:55:25.900	35.17	-4.08	1	-	-9.0	3	10	eq	37	IGN
1994236	8/24/1994	9:30:42.100	35.45	-3.94	0	-	3.4	19	7	eq	38	IGN
1994239	8/27/1994	23:41:37.700	35.02	-3.69	2	-	3.5	25	7	eq	39	IGN
1994250	9/07/1994	1:02:30.900	35.49	-3.80	0	-	3.5	24	4	eq	40	IGN
1994257	9/14/1994	2:55:28.900	35.39	-3.97	10	-	3.5	27	5	eq	41	IGN
1994260	9/17/1994	2:25:12.000	35.18	-3.94	10	-	-9.0	5	4	eq	42	IGN
1994280	10/07/1994	8:52:43.000	35.24	-4.11	10	-	-9.0	18	5	eq	43	IGN
1994298	10/25/1994	1:24:20.200	35.38	-3.96	8	-	2.8	18	6	eq	44	IGN
1995036	2/05/1995	13:14:44.700	35.37	-3.88	1	-	3.0	9	6	eq	45	IGN
1995067	3/08/1995	16:07:07.700	35.47	-3.80	15	-	2.6	12	4	eq	46	IGN
1995073	3/14/1995	10:29:36.800	35.24	-3.94	24	-	3.3	22	6	eq	47	IGN
1995078	3/19/1995	3:41:19.200	35.06	-3.91	29	-	3.1	28	5	eq	48	IGN
1995085	3/26/1995	15:52:54.300	35.48	-4.65	16	-	2.8	24	4	eq	49	IGN
1995126	5/06/1995	9:44:50.300	35.23	-3.58	33	-	3.2	18	4	eq	50	IGN
1995178	6/27/1995	22:18:59.300	35.29	-3.78	20	-	3.0	8	0	eq	51	IGN

1995181	6/30/1995	3:35:12.500	35.17	-4.11	1	-	2.8	29	4	eq	52	IGN
1995195	7/14/1995	19:03:48.700	35.30	-3.96	9	-	2.8	22	3	eq	53	IGN

GTDB: Spanish Dataset: Region: Melilla

origin time			lat	lon	dep	d	ml	ndef	nass	etype	evid	author
1993143	5/23/1993	7:40:56.600	35.21	-2.46	14	-	4.4	41	14	eq	ev157	IGN
1993143	5/23/1993	8:44:41.000	35.19	-2.65	20	-	-9.0	10	2	eq	ev158	IGN
1993143	5/23/1993	9:58:30.200	34.99	-2.42	12	-	3.2	29	10	eq	ev159	IGN
1993143	5/23/1993	10:02:34.400	35.21	-2.16	3	-	2.6	18	2	eq	ev160	IGN
1993143	5/23/1993	11:17:01.600	35.19	-2.37	2	-	3.3	24	4	eq	ev161	IGN
1993143	5/23/1993	23:03:53.400	35.27	-2.46	13	-	3.1	29	13	eq	ev162	IGN
1993143	5/23/1993	23:39:17.500	35.25	-2.37	1	-	2.8	17	8	eq	ev163	IGN
1993152	6/01/1993	23:04:19.300	35.01	-2.41	0	-	2.9	18	2	eq	ev164	IGN
1993160	6/09/1993	22:45:03.600	35.26	-2.36	2	-	3.7	30	8	eq	ev165	IGN
1993193	7/12/1993	2:53:17.200	35.16	-2.35	7	-	3.1	35	11	eq	ev166	IGN
1993199	7/18/1993	15:32:27.800	35.28	-2.40	6	-	3.1	26	3	eq	ev167	IGN
1994084	3/25/1994	21:24:32.000	35.32	-2.77	10	-	-9.0	12	9	eq	ev168	IGN
1995085	3/26/1995	14:23:55.200	34.95	-2.49	28	-	3.5	21	4	eq	ev169	IGN
1995156	6/05/1995	9:29:35.000	35.16	-2.27	1	-	3.4	26	4	eq	ev170	IGN
1995168	6/17/1995	23:46:16.400	35.45	-2.66	29	-	2.9	14	1	eq	ev171	IGN

GTDB: Spanish Dataset: Region: Fuente

origin time			lat	lon	dep	d	ml	ndef	nass	etype	evid	author
1993321	11/17/1993	13:58:13.200	38.28	-5.28	0	-	2.6	9	4	qb	54	IGN
1994133	5/13/1994	10:28:29.100	38.22	-5.17	0	-	2.7	19	2	qb	55	IGN
1994192	7/11/1994	13:05:02.500	38.24	-5.22	0	-	2.9	10	4	qb	56	IGN
1994207	7/26/1994	13:08:17.000	38.26	-5.30	0	-	2.7	8	4	qb	57	IGN
1994284	10/11/1994	10:15:20.300	38.23	-5.11	0	-	2.9	7	2	qb	59	IGN
1994327	11/23/1994	9:20:54.900	38.26	-5.15	0	-	2.9	22	4	qb	60	IGN
1995033	2/02/1995	10:39:37.900	38.28	-5.14	0	-	2.7	8	4	qb	61	IGN
1995037	2/06/1995	14:04:14.600	38.28	-5.24	0	-	2.6	6	4	qb	62	IGN
1995038	2/07/1995	11:47:27.200	38.22	-5.10	0	-	2.8	6	2	qb	63	IGN
1995054	2/23/1995	11:01:48.000	38.30	-5.17	0	-	2.7	8	2	qb	64	IGN
1995058	2/27/1995	10:56:25.700	38.20	-5.12	0	-	2.8	6	2	qb	65	IGN
1995061	3/02/1995	10:51:25.900	38.24	-5.12	0	-	2.7	8	4	qb	66	IGN
1995061	3/02/1995	14:04:30.500	38.29	-5.25	0	-	2.6	6	2	qb	67	IGN
1995065	3/06/1995	10:30:39.100	38.19	-5.07	0	-	2.8	6	4	qb	68	IGN
1995066	3/07/1995	14:04:13.700	38.26	-5.29	0	-	2.5	8	4	qb	69	IGN
1995067	3/08/1995	12:00:04.900	38.26	-5.17	0	-	2.9	6	4	qb	70	IGN
1995069	3/10/1995	10:34:30.100	38.23	-5.14	0	-	2.8	12	4	qb	71	IGN
1995072	3/13/1995	10:47:17.200	38.20	-5.12	0	-	2.7	14	4	qb	72	IGN
1995073	3/14/1995	14:02:19.300	38.26	-5.36	0	-	2.8	12	4	qb	73	IGN
1995074	3/15/1995	10:02:00.200	38.25	-5.12	0	-	2.6	8	4	qb	74	IGN
1995080	3/21/1995	11:32:53.000	38.30	-5.17	0	-	2.8	17	4	qb	75	IGN
1995080	3/21/1995	14:04:26.400	38.39	-5.35	0	-	2.7	8	2	qb	76	IGN
1995086	3/27/1995	11:21:51.900	38.24	-5.18	0	-	2.6	10	2	qb	77	IGN
1995088	3/29/1995	9:51:30.800	38.28	-5.13	0	-	2.6	12	4	qb	78	IGN
1995094	4/04/1995	13:03:30.800	38.27	-5.25	0	-	2.8	6	4	qb	80	IGN
1995096	4/06/1995	9:30:19.800	38.18	-5.12	0	-	2.6	10	4	qb	81	IGN
1995100	4/10/1995	13:04:26.300	38.26	-5.31	0	-	2.6	9	4	qb	82	IGN

1995102	4/12/1995	9:37:08.600	38.32	-5.24	0	-	2.6	15	4	qb	83	IGN
1995116	4/26/1995	13:06:39.700	38.30	-5.28	0	-	2.6	8	4	qb	84	IGN
1995123	5/03/1995	11:25:01.600	38.21	-5.11	0	-	2.7	12	4	qb	85	IGN
1995125	5/05/1995	11:18:57.600	38.31	-5.17	0	-	2.6	10	4	qb	86	IGN
1995125	5/05/1995	13:04:27.000	38.30	-5.34	0	-	2.5	6	4	qb	87	IGN
1995139	5/19/1995	9:14:58.600	38.28	-5.16	0	-	2.7	8	4	qb	88	IGN
1995144	5/24/1995	9:12:21.300	38.17	-5.09	0	-	2.5	15	2	qb	89	IGN
1995150	5/30/1995	12:43:03.400	38.28	-5.32	0	-	2.8	11	4	qb	90	IGN
1995160	6/09/1995	9:05:30.300	38.21	-5.16	1	-	2.5	14	2	qb	91	IGN
1995165	6/14/1995	9:02:11.000	38.21	-5.11	0	-	2.6	10	0	qb	92	IGN
1995166	6/15/1995	9:50:51.700	38.20	-5.15	0	-	2.7	10	2	qb	93	IGN
1995173	6/22/1995	12:44:41.600	38.34	-5.28	0	-	2.5	6	0	qb	94	IGN
1995177	6/26/1995	10:44:07.900	38.26	-5.13	0	-	2.8	7	2	qb	95	IGN
1995179	6/28/1995	9:13:11.700	38.28	-5.13	0	-	2.6	8	4	qb	96	IGN
1995179	6/28/1995	10:07:27.800	38.28	-5.15	0	-	2.9	10	4	qb	97	IGN
1995186	7/05/1995	9:25:47.000	38.27	-5.16	0	-	2.7	12	2	qb	98	IGN
1995188	7/07/1995	9:43:26.100	38.19	-5.21	0	-	2.6	6	2	qb	99	IGN
1995193	7/12/1995	9:06:13.300	38.26	-5.12	0	-	2.7	14	2	qb	100	IGN

GTDB: Spanish Dataset: Region: Puertollano

origin time			lat	lon	dep	d	ml	ndef	nass	etype	evid	author
1994129	5/09/1994	12:26:41.300	38.60	-4.10	0	-	2.8	13	6	qb	103	IGN
1994269	9/26/1994	14:22:39.800	38.60	-4.11	0	-	2.8	7	5	qb	106	IGN
1995037	2/06/1995	13:29:16.300	38.63	-4.11	0	-	2.6	12	6	qb	107	IGN
1995038	2/07/1995	13:28:46.400	38.57	-4.09	0	-	2.6	8	3	qb	108	IGN
1995045	2/14/1995	13:27:33.400	38.70	-4.16	0	-	2.9	8	3	qb	109	IGN
1995047	2/16/1995	13:28:15.500	38.69	-4.12	0	-	2.7	6	3	qb	112	IGN
1995058	2/27/1995	13:27:29.000	38.59	-4.11	0	-	2.8	5	6	qb	113	IGN
1995065	3/06/1995	13:27:56.800	38.67	-4.14	0	-	2.9	6	6	qb	114	IGN
1995073	3/14/1995	13:27:37.800	38.63	-4.16	0	-	2.7	6	6	qb	115	IGN
1995087	3/28/1995	12:27:26.300	38.61	-4.10	0	-	2.6	9	6	qb	116	IGN
1995090	3/31/1995	12:27:23.800	38.58	-4.12	0	-	2.8	5	6	qb	117	IGN
1995095	4/05/1995	12:27:33.400	38.62	-4.09	0	-	2.7	11	6	qb	118	IGN
1995096	4/06/1995	12:28:23.000	38.57	-4.07	0	-	2.7	8	6	qb	119	IGN
1995100	4/10/1995	12:27:42.700	38.62	-4.11	0	-	2.6	8	6	qb	120	IGN
1995114	4/24/1995	12:28:26.000	38.66	-4.14	0	-	2.5	6	6	qb	121	IGN
1995117	4/27/1995	19:49:35.000	38.55	-3.86	3	-	2.9	32	6	qmt	122	IGN
1995122	5/02/1995	12:27:55.700	38.57	-4.10	0	-	2.6	8	6	qb	123	IGN
1995128	5/08/1995	12:28:09.200	38.62	-4.13	0	-	2.5	18	3	qb	124	IGN
1995129	5/09/1995	12:28:40.800	38.60	-4.12	0	-	2.6	10	6	qb	125	IGN
1995131	5/11/1995	12:28:19.200	38.70	-4.16	0	-	2.7	8	3	qb	126	IGN
1995142	5/22/1995	12:27:21.300	38.59	-4.03	0	-	2.8	8	3	qb	127	IGN
1995145	5/25/1995	12:28:07.400	38.73	-4.17	0	-	2.6	9	3	qb	128	IGN
1995156	6/05/1995	12:27:36.500	38.67	-4.14	0	-	2.8	9	3	qb	129	IGN
1995158	6/07/1995	12:27:52.400	38.60	-4.11	0	-	2.5	9	3	qb	131	IGN
1995160	6/09/1995	12:22:59.100	38.59	-4.14	0	-	2.5	14	3	qb	132	IGN
1995166	6/15/1995	12:27:57.000	38.60	-4.14	0	-	2.6	10	3	qb	134	IGN
1995167	6/16/1995	12:24:56.400	38.71	-3.98	0	-	2.6	5	3	qb	135	IGN
1995170	6/19/1995	12:29:29.600	38.62	-4.10	1	-	2.5	13	6	qb	136	IGN
1995171	6/20/1995	12:28:06.600	38.90	-4.10	0	-	2.7	7	6	qb	137	IGN
1995172	6/21/1995	12:28:38.100	38.62	-4.11	0	-	2.6	10	3	qb	138	IGN
1995173	6/22/1995	12:23:01.700	38.62	-4.11	0	-	2.8	16	3	qb	139	IGN

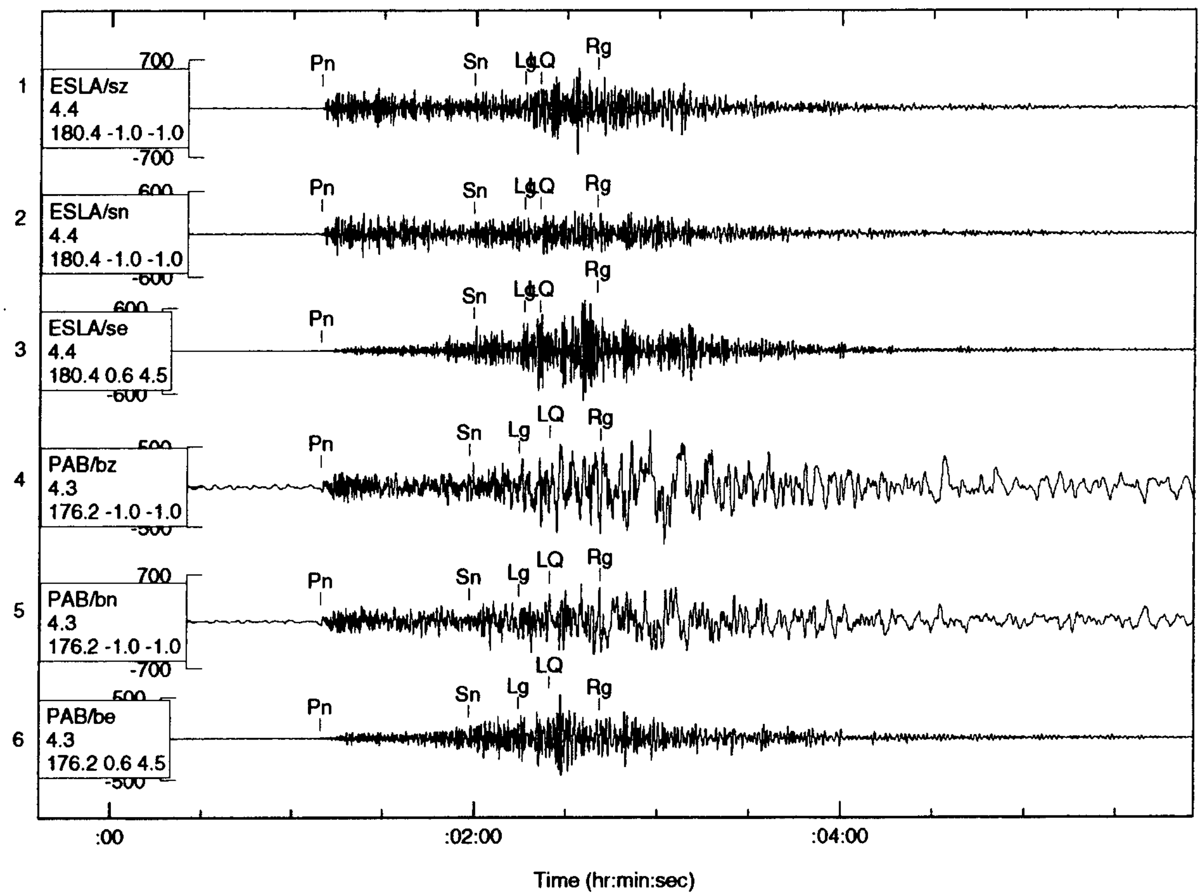
1995179	6/28/1995	12:23:37.700	38.65	-4.14	0	-	2.5	10	6	qb	140	IGN
1995184	7/03/1995	12:28:29.100	38.64	-4.09	0	-	2.6	15	6	qb	141	IGN
1995188	7/07/1995	12:23:00.900	38.59	-4.13	0	-	2.6	8	3	qb	142	IGN
1995191	7/10/1995	12:24:52.200	38.64	-4.08	0	-	2.5	14	3	qb	143	IGN
1995193	7/12/1995	12:23:33.700	38.70	-4.13	0	-	2.5	18	3	qb	144	IGN
1995194	7/13/1995	12:26:11.800	38.57	-4.11	0	-	2.5	8	3	qb	145	IGN

GTDB: Spanish Dataset: Region: Canary

origin time			lat	lon	dep	d	ml	ndef	nass	etype	evid	author
1993236	8/24/1993	22:51:53.000	28.30	-16.16	18	-	-9.0	0	2	eq	147	IGN
1993293	10/20/1993	14:57:39.000	28.03	-16.11	21	-	-9.0	10	2	eq	149	IGN

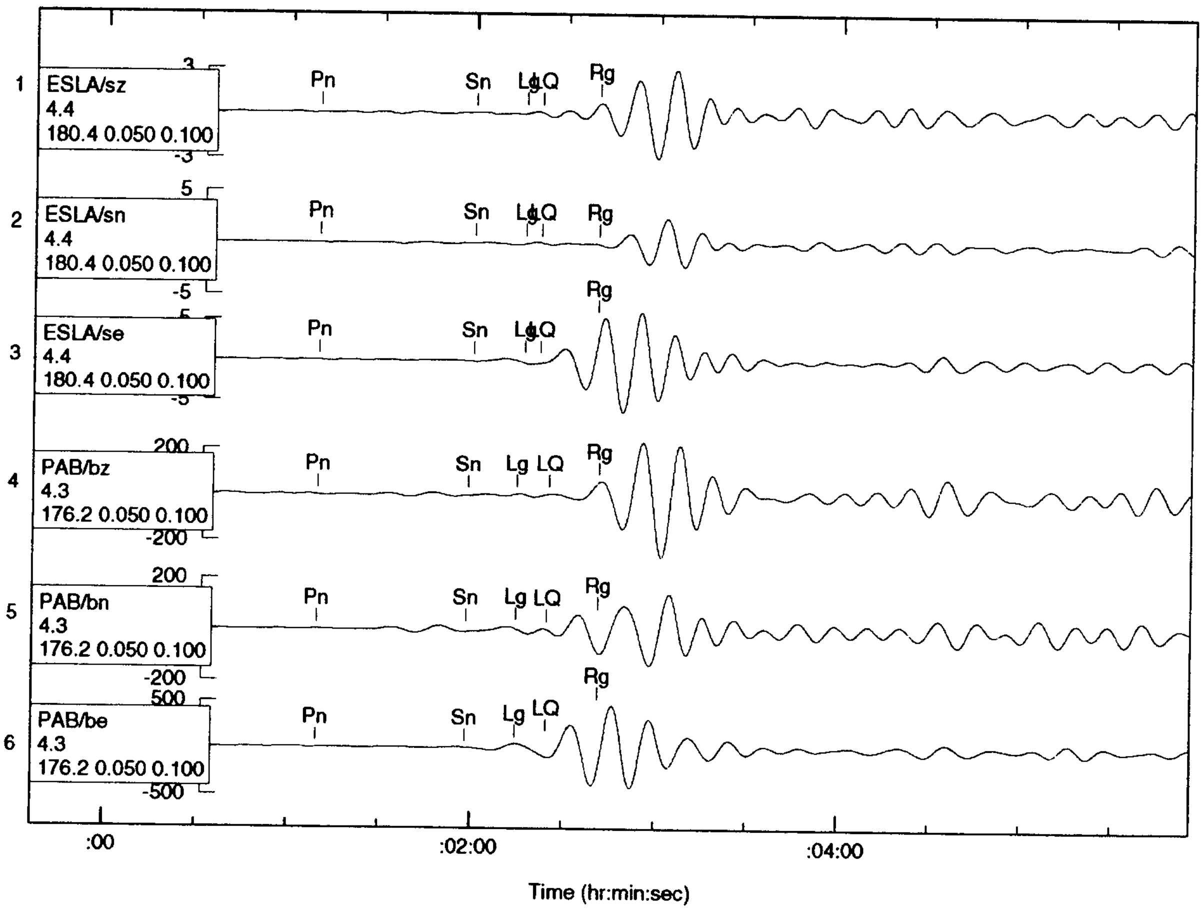
Sample Waveform Plots

Plots in this section are representative of the data available for events in the Spanish Dataset. Station-to-event distance in degrees is given in the captions for each station mentioned.



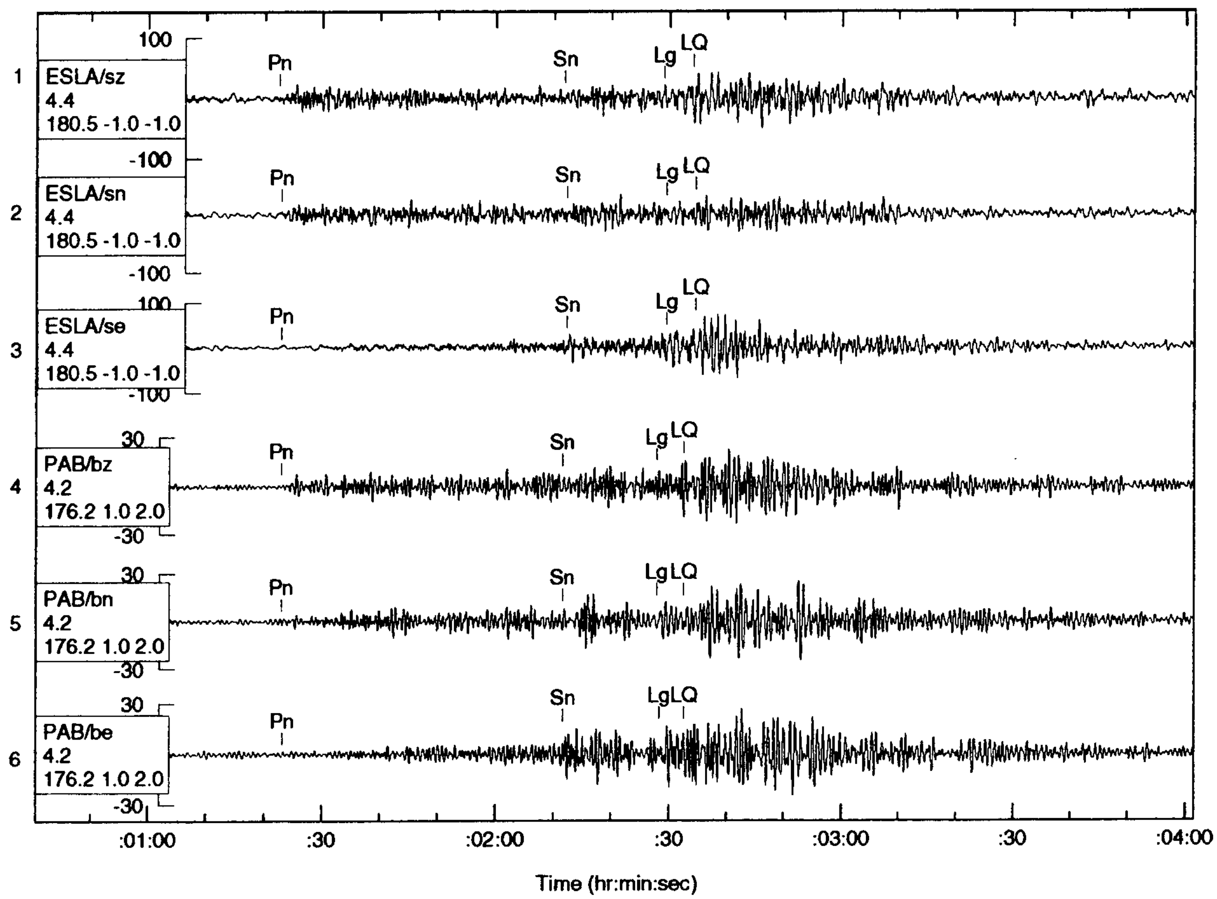
Time scale: two units = one minute.

Figure 18: Alhucemas Earthquake ev22 (ML 4.6, h 13). Three components are shown at stations PAB (4.3 deg.) and ESLA (4.4 deg). The E-W components are filtered at 0.6 - 4.5 Hz. Others are unfiltered.



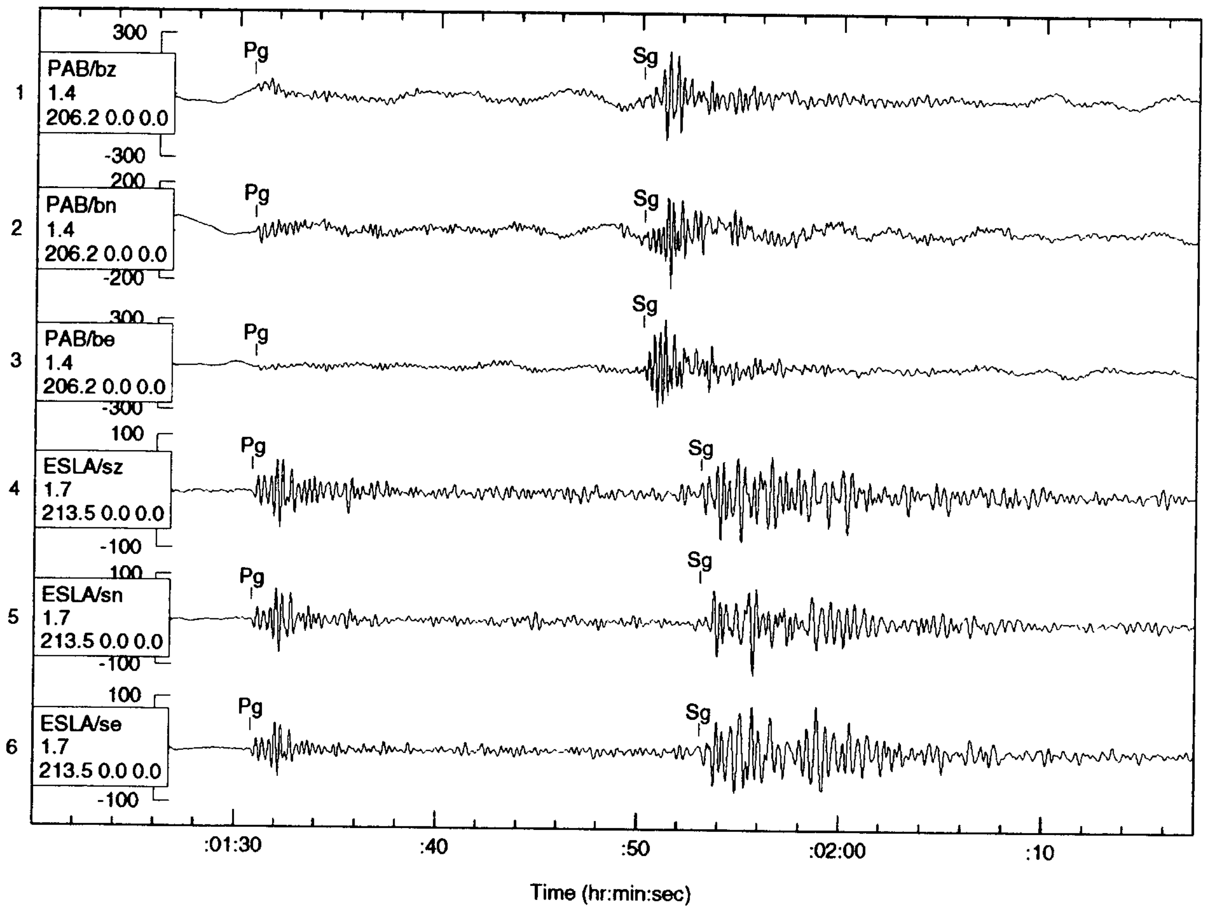
Time scale: two units = one minute.

Figure 19: Alhucemas Earthquake ev22 (ML 4.6, h 13). Three components are shown at stations PAB (4.3 deg.) and ESLA (4.4 deg). All traces are filtered at 0.05 - 0.10 Hz.



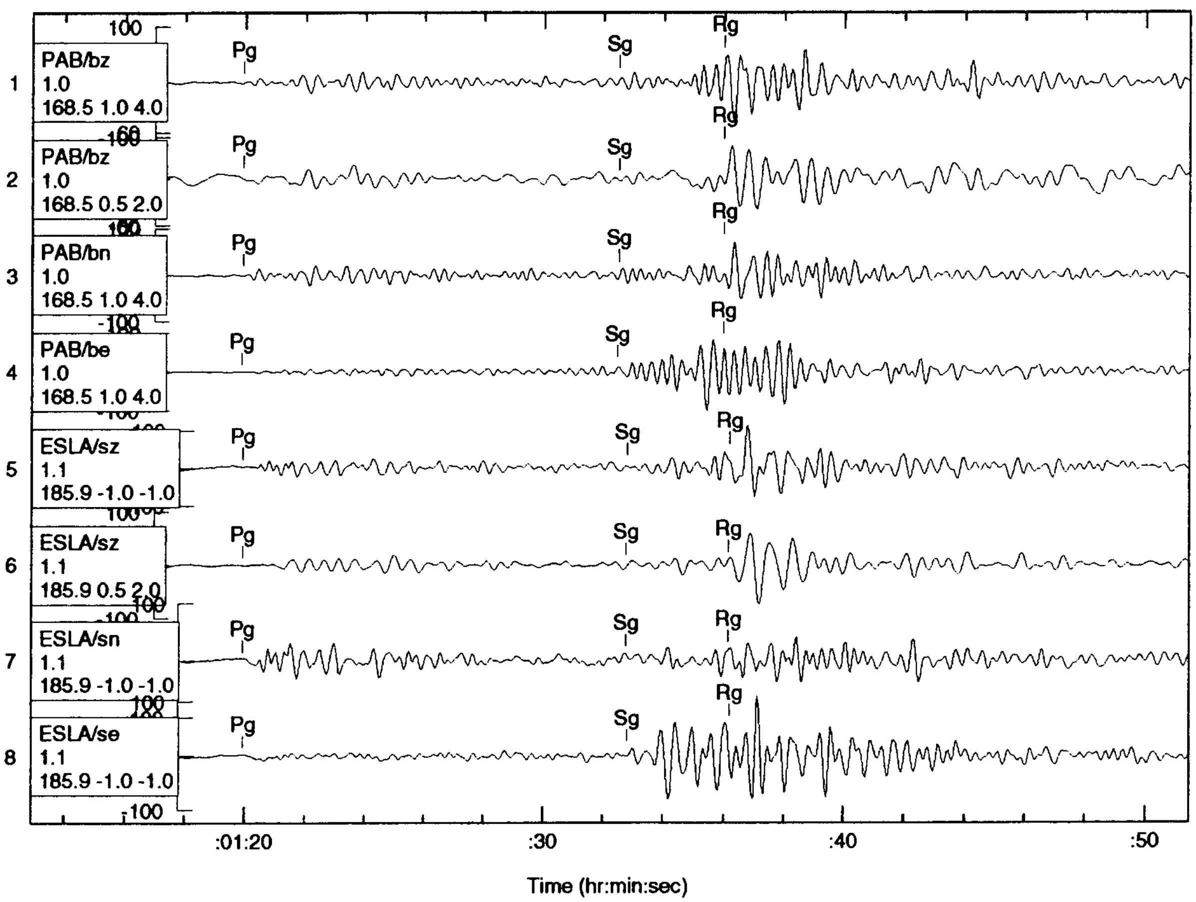
Time scale: six units = one minute.

Figure 20: Alhucemas Earthquake ev35 (ML 3.6, h 0). Three components are shown at stations PAB (4.2 deg.) and ESLA (4.4 deg.). PAB traces are filtered at 1 - 2 Hz. ESLA traces are unfiltered.



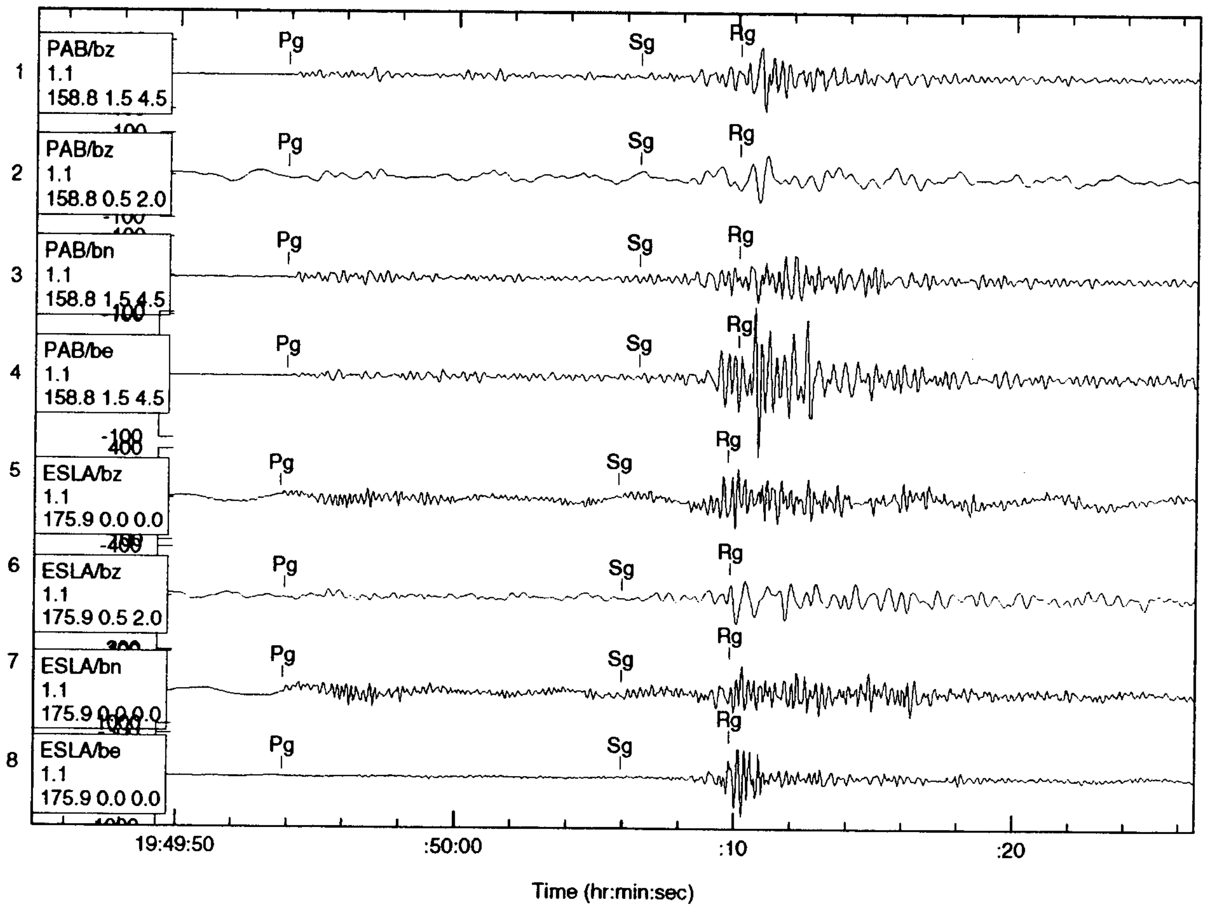
Time scale: five units = ten seconds.

Figure 21: Fuente Blast ev60 (ML 2.9, h 0). Three components are shown at stations PAB (1.4 deg.) and ESLA (1.7 deg.). All traces are unfiltered.



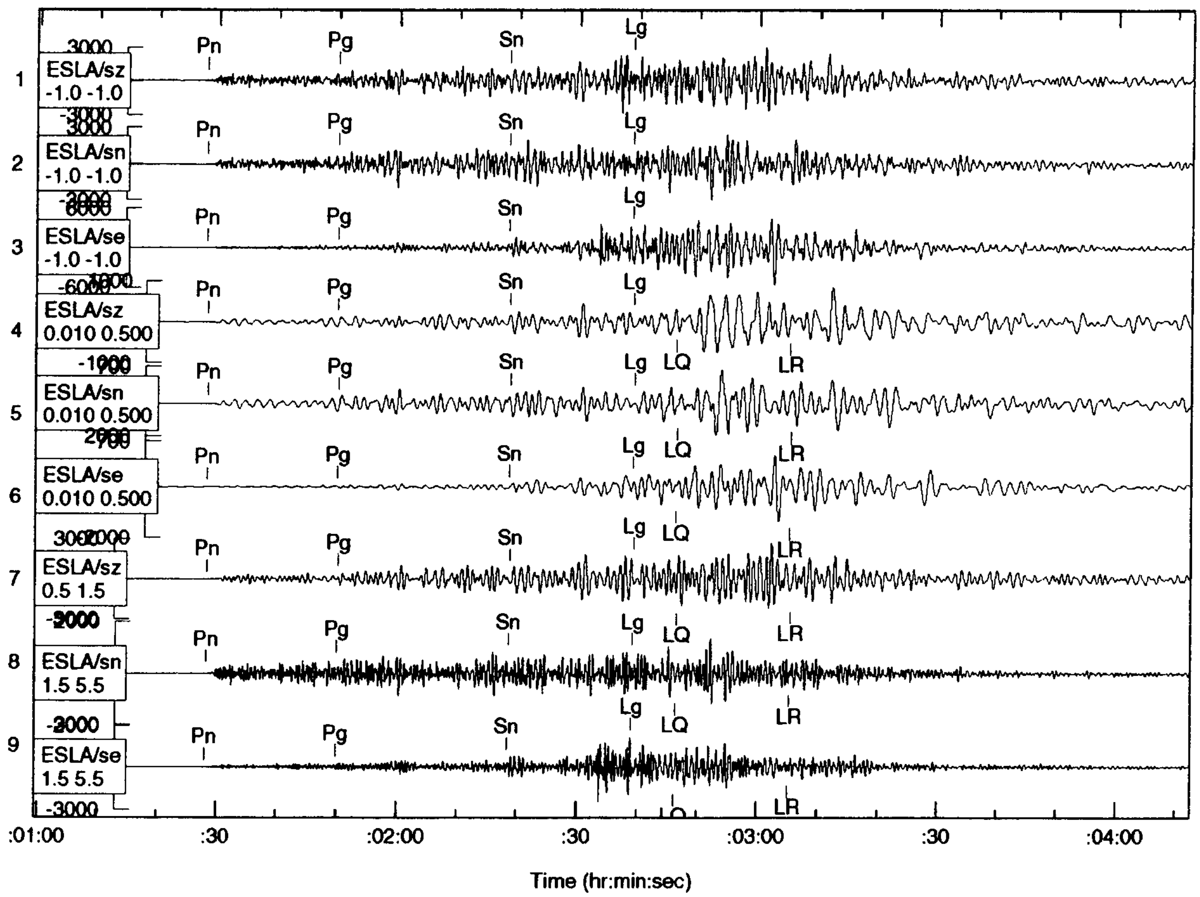
Time scale: five units = ten seconds.

Figure 22: Puertollano Blast ev103 (ML 2.8, h 0). Three components are shown at stations PAB (1.0 deg.) and ESLA (1.1 deg). Traces are: 1, 3, 4) 1 - 4 Hz; 2) 0.5 - 2.0 Hz; 5, 7, 8) unfiltered; 6) 0.5 - 2.0 Hz.



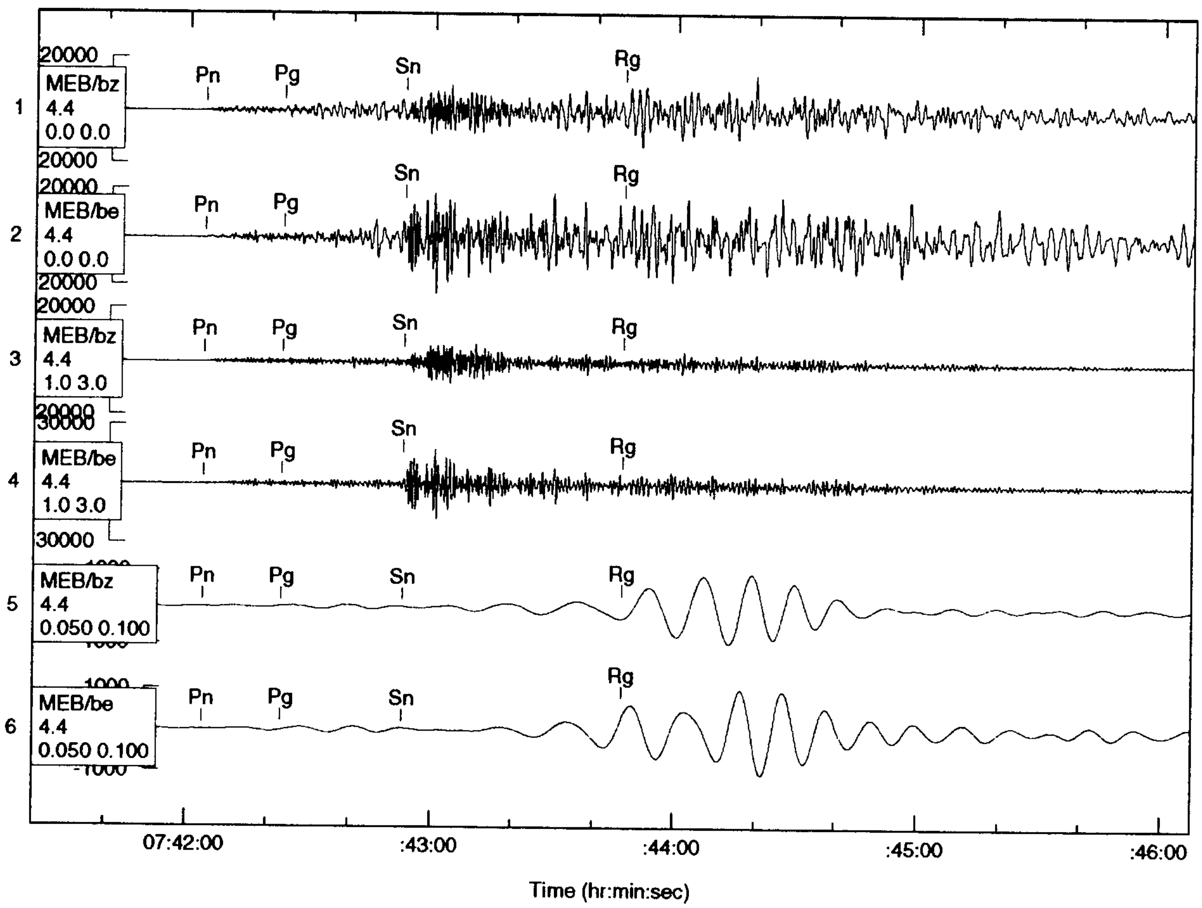
Time scale: five units = ten seconds.

Figure 23: Puertollano Mine Tremor ev122 (ML 2.9, h 3). Three components are shown at stations PAB (1.1 deg.) and ESLA (1.1 deg). Traces are: 1,3,4) 1.5 - 4.5 Hz; 2) 0.5 - 2.0 Hz; 5,7,8) unfiltered; 6) 0.5 - 2.0 Hz.



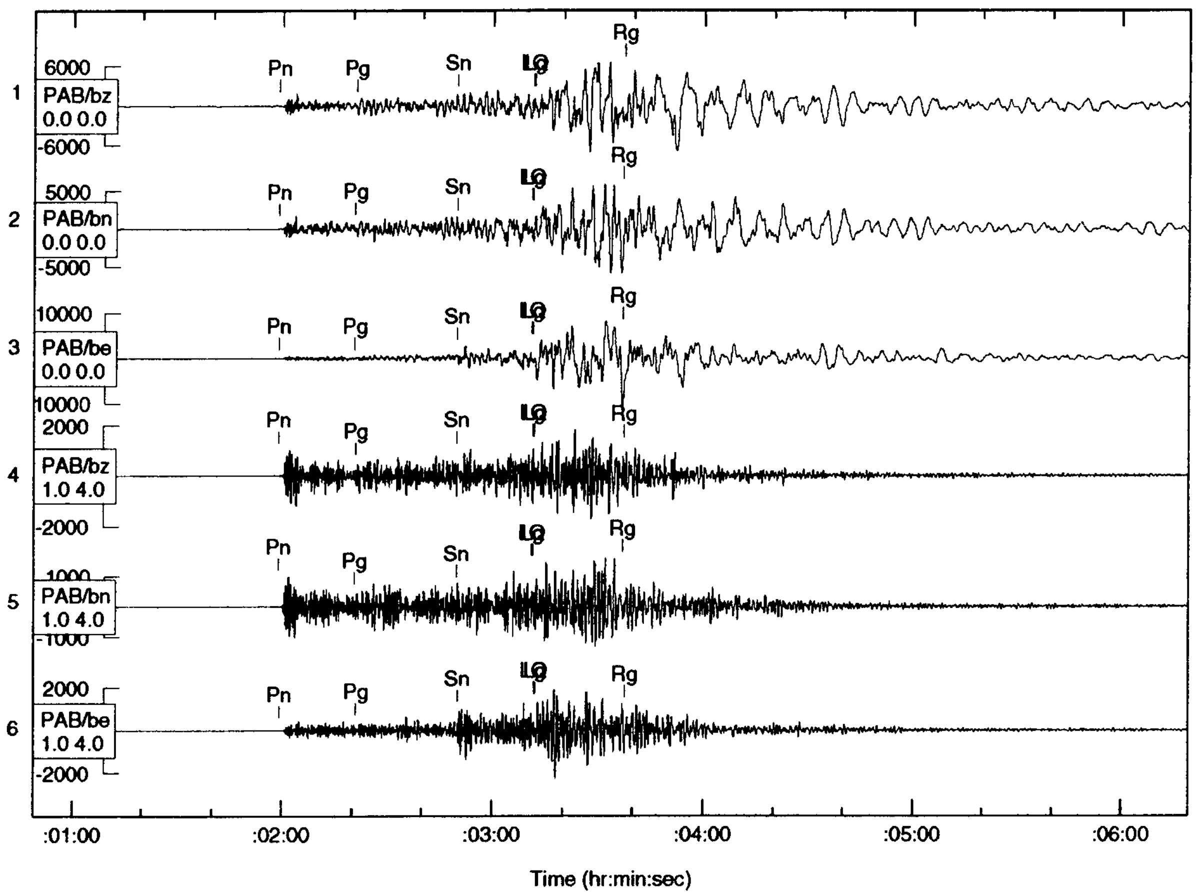
Time scale: six units = one minute.

Figure 24: Melilla Earthquake ev157 (ML 4.4, h 14). Three components are shown at station ESLA (4.6 deg.). Traces are: 1-3) unfiltered; 4-6) 0.01 - 0.5 Hz; 7) 0.50 - 1.50 Hz; 8-9) 1.50 - 5.50 Hz. Predicted arrivals for LQ and LR are plotted beneath the waveforms.



Time scale: three units = one minute.

Figure 25: Melilla Earthquake ev157 (ML 4.4, h 14). BHZ and BHE components are shown at station MEB (4.4 deg). Traces are: 1-2) unfiltered; 3-4) 1 - 3 Hz; 5-6) 0.05 - 0.10 Hz.



Time scale: three units = one minute.

Figure 26: Melilla Earthquake ev157. Three components are shown at station PAB (ML 4.4, h 14). Traces are: 1-3) unfiltered; 4-6) 1 - 4 Hz. Lg and LQ have approximately the same arrival time.

Chapter 4

The GII/Galilee Data Set

The GII/Galilee dataset is an example of a complete "ground-truth" dataset where regional waveforms are available for well-located events of known source type.

This dataset, comprising 47 events located in northern Israel, was contributed to the GTDB project by the Geophysical Institute of Israel (GII, formerly the Institute for Petroleum Research and Geophysics, IPRG). This is a subset of events collected for a discrimination study by Gitterman and van Eck (1993). We used updated event parameters which were revised under the DOE contract described by Gitterman *et al.* (1996). The latter reference describes the Galilee dataset in addition to other datasets compiled for Israel. GII scientists provided the entire dataset as listed below.

- Event locations based on the bulletin of the Israel Seismic Network (ISN). Events occurred between 1987 and 1991. Magnitudes are between ML 1.0 and ML 2.6.
- 713 seismic waveforms recorded by the ISN: Event to station distances range from less than 0.1 degrees to 3 degrees. The largest of the events was recorded at 28 ISN stations, and the smallest at 4 ISN stations.
- Event identifications: 19 quarry blasts with known yields and 28 earthquakes.
- Name and location of active quarries in the region.
- Phase arrival times and identifications for 687 phases.

Event parameters and waveforms for this dataset were converted to CSS3.0 format by programs written by Ivan Henson. Figure 27 shows event locations. Figure 28 shows the inset with earthquakes and blasts.

About the Israel Seismic Network

Figure 29 shows the Israel Seismic Network (ISN) during the time the GII/Galilee Dataset was recorded (1987-91). At the time of these events, the ISN employed SP (1 Hz) seismometers (either Teledyne-Geotech S-13 or Mark Products L4C). Five of the stations (DOR,

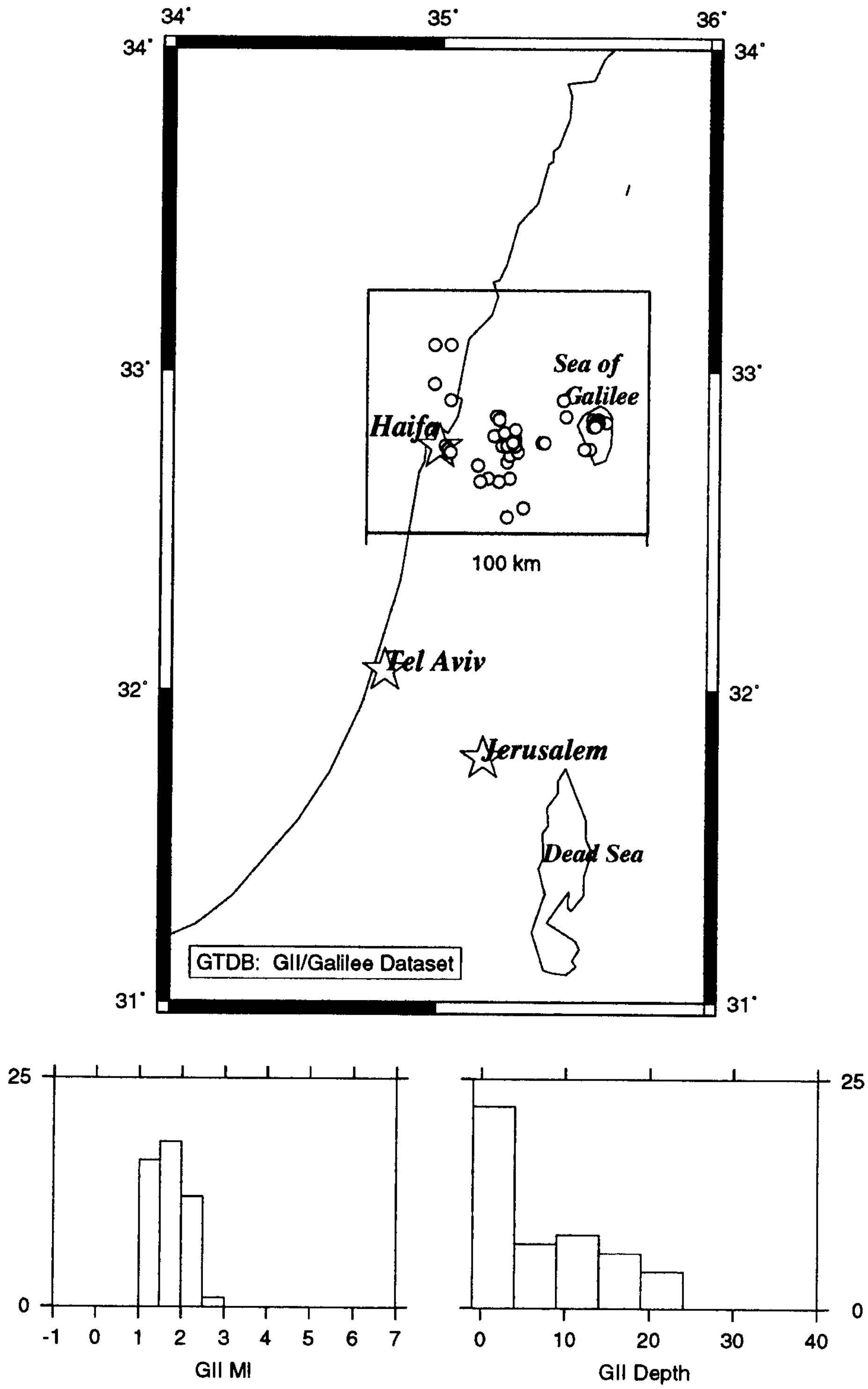


Figure 27: The Galilee Dataset. Location, magnitude, and depth estimates were supplied by the GII. The quarry blasts have a depth of zero. The inset is shown in Figure 28.

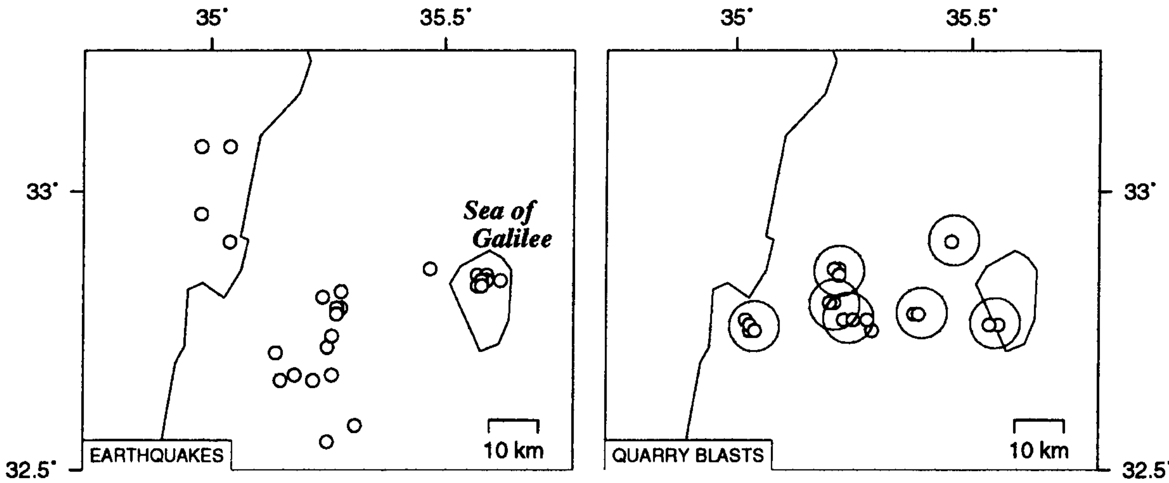


Figure 28: The Galilee Dataset. Earthquakes are plotted on the map at left. Quarry blasts are plotted on the map at right. The locations of the quarries responsible for the blasts are shown by open circles scaled to about 10 km diameter.

MKT, ZNT, ATZ, SGI) have three-component sets of instruments. Data were bandpass filtered at 0.2-12.5 Hz and digitally recorded at 50 samp/sec by the ISDA system (Shapira and Avirav, 1990). The network has been upgraded since this dataset was collected.

The original station names and locations, sent to us by GII, were changed slightly to conform to the CSS3.0 *site* tables. Additional information about stations in the ISN is available on the GTDB Web Site[27].

About the Blasts

The nineteen blasts included in this dataset were confirmed by GII staff through FAX and telephone communication with the quarries. For each blast included, there is an associated mine, yield in tons, and time delay in seconds.

The seven quarries represented in this dataset are currently active, open-pit stone quarries producing materials for the constuction of buildings and roads. Mine locations, provided by GII scientists, are listed below. Events in the GII/Galilee Dataset are listed to the right of the corresponding mines (additional event parameters are listed on page 73).

Mine Name	Lat	Lon	GTDB GII/Galilee Events
Carmel	32.758	35.040	ev207, ev211, ev212, ev223, ev230
Shefaram	32.797	35.211	ev209, ev214, ev215, ev219
Tamra	32.858	35.220	ev213, ev217, ev239

[27]URL: http://es1.multimax.com/~gtdb/index.html

Hanaton	32.773	35.241	ev221, ev224
Golani	32.782	35.397	ev210, ev236, ev240
Kadarim	32.913	35.465	ev238
Poria	32.764	35.553	ev226, ev234

Shapira (1991) estimates that only 10% of the events recorded by the ISN are earthquakes and the rest are blasts from quarries in Israel and Jordan. An expanded list of active mines in the region can be found on the GTDB Web Site[28].

About the Earthquakes

The GII/Galilee Dataset includes 28 earthquakes located in northern Israel and recorded by the Israel Seismic Network between 1987 and 1991. Magnitudes range between 1.0 ML and 2.4 ML, and depths are estimated to be less than 25 km.

Although some of the earthquakes are located near (within 10 km) quarry sites, GII seismologists do not presume that any of the earthquake activity was induced by quarry activity (Y. Gitterman, personal communication).

Interactive Waveform Analysis

In order to maintain consistency of analysis procedures between this and other GTDB datasets, the GII events were re-analyzed by Flori Ryall. The data contained readings done by the GII that were limited to stations at distances less than about 1.5 degrees, apparently sufficient to obtain acceptable location results. The Israeli earth model assumed a crustal thickness of 28.2 km, and the Pg/Pn crossover for surface events was at about 1.4 degrees distance.

The main result of this analysis was to time and identify phase arrivals on the more distant recordings. Most of the changes to the GII readings involved minor retiming of phase picks, and addition of the Rg pick whenever the onset time of that phase was relatively clear. A lack of Rg does not mean that the phase was absent, only that the onset was too ambiguous to time with any degree of certainty. The GII analyst also identified phases as Pn or Sn for all distances including very local distances. In such cases, following the convention we have used in previous datasets, the phase names were changed to Pg or Sg for distances less than 1.4 degrees and were not changed beyond that distance.

Five of the stations (DOR, MKT, ZNT, ATZ, SGI) have three-component sets of instruments, although all components were not available for most of the events. The majority of S-type phases were read on vertical channels, since most of the stations consisted of vertical instruments only, and horizontal waveforms were usually missing.

The results of this analysis are 1,167 phases associated with the 47 events. The phases were timed and indentified on waveforms from 43 different stations of the ISN. Phase types have the following distribution: Pn - 104; Pg - 487; Sg - 403; Sn - 2; Lg - 106; Rg - 65.

[28]URL: http://es1.multimax.com/~gtdb/index.html

Waveform Quality

For the GII/Galilee Dataset, we have chosen to include all available ISN waveforms for each event regardless of quality. Of the 713 waveforms comprising this dataset, problems were noted (in the *wfedit* tables) for 57 traces. Most of these problems were glitches. There may be additional problems with the waveforms that we have not documented.

Event Lists

In the event listings that follow, the origin time, latitude, longitude, depth, and magnitude are defined by researchers from the Geophysical Institute of Israel (GII). The parameter "ndef" represents the number of defining phases used by GII to define the event. The parameter "nass" is the number of GTDB phases associated with the event.

In a slight departure from the CSS3.0 Schema (Anderson, *et al.* 1990), the event type field, etype, is either "eq" (earthquake) or "qb" (quarry blast). Gitterman *et al.* (1996) notes that the values of ML for the blasts are probably overestimated.

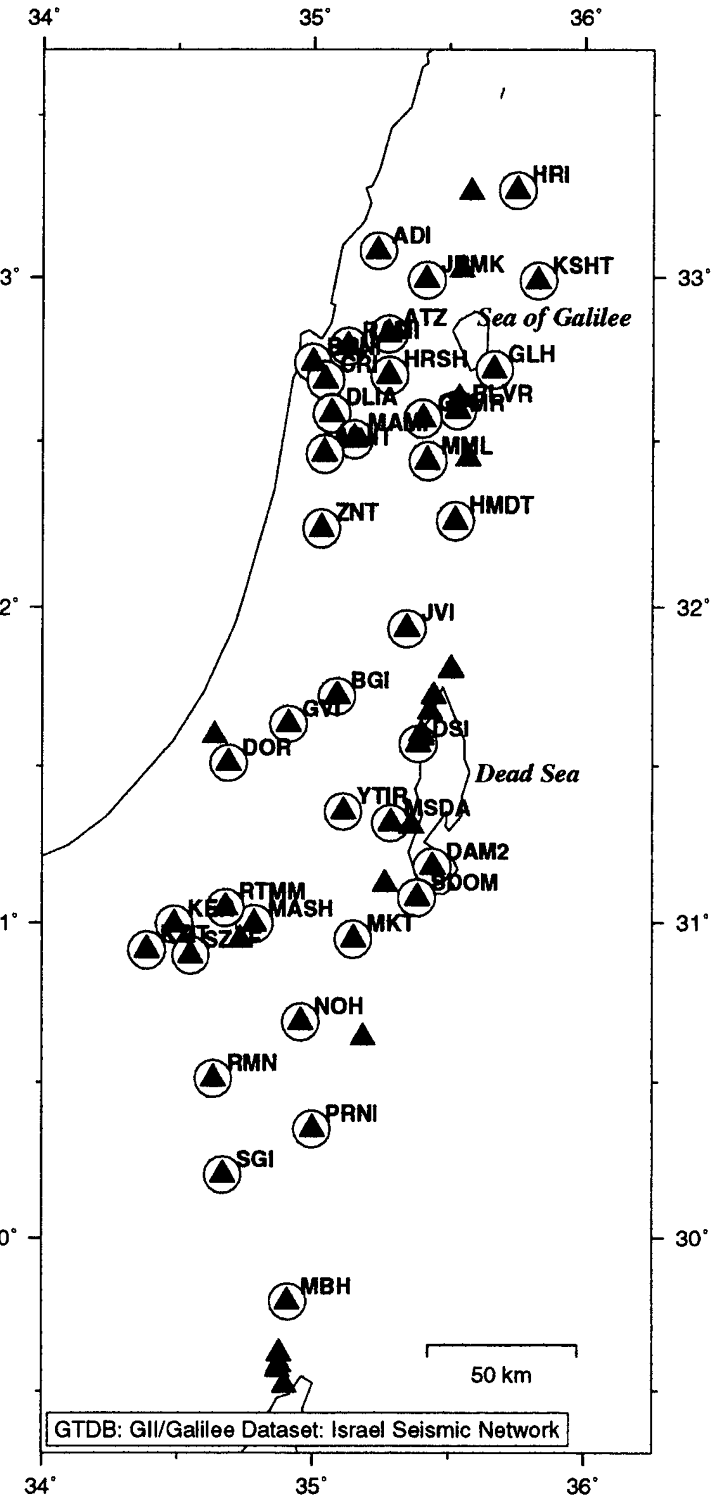


Figure 29: The Israel Seismic Network. Triangles represent stations in the Israel Seismic Network. The GII/Galilee dataset includes waveform data from the ISN stations highlighted by the circles. To make the map more legible, the following station names were left off: SAGI (at the same location as SGI); MZDA (near MSDA); BGIO (at the same location as BGI); ZNL (at the same location as ZNT); MMR (at the same location as JRMK).

GTDB: GII/Galilee Dataset: Earthquakes

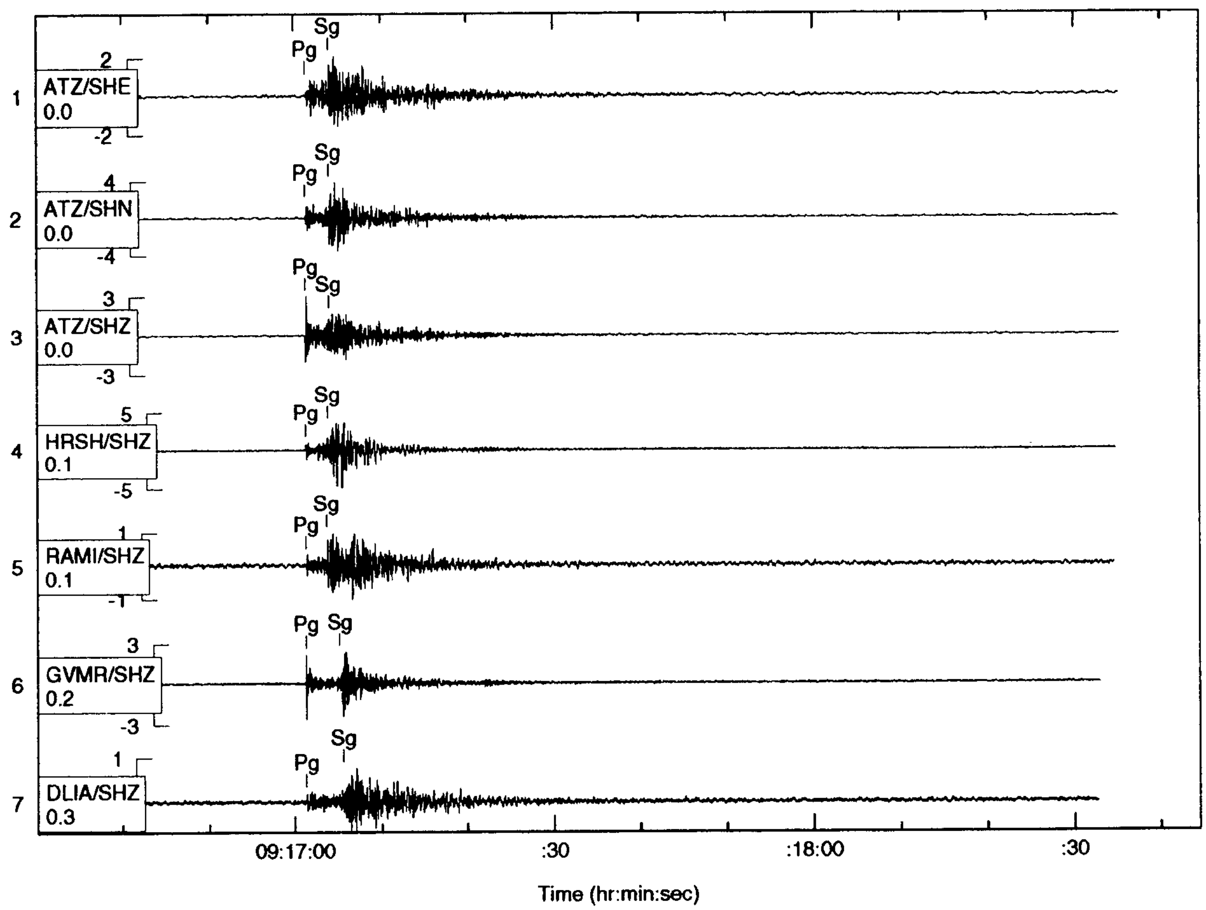
origin time			lat	lon	dep	ml	ndef	nass	etype	evid	author
1987280	10/07/1987	15:15:04.700	32.67	35.26	12	1.9	17	20	eq	201	GII
1988055	2/24/1988	15:37:26.600	32.72	35.25	10	1.5	15	15	eq	202	GII
1988063	3/03/1988	13:15:25.400	32.74	35.26	12	1.1	14	16	eq	203	GII
1988211	7/29/1988	23:33:28.600	32.66	35.22	10	1.4	12	16	eq	204	GII
1988219	8/06/1988	14:49:27.500	32.71	35.14	12	2.1	22	51	eq	205	GII
1989104	4/14/1989	5:53:33.300	32.67	35.18	17	1.3	14	18	eq	206	GII
1989231	8/19/1989	9:17:05.400	32.79	35.28	21	1.7	15	48	eq	208	GII
1990233	8/21/1990	6:22:23.000	32.66	35.15	16	1.8	12	31	eq	218	GII
1990247	9/04/1990	16:44:21.100	32.91	35.04	0	1.5	12	18	eq	220	GII
1990259	9/16/1990	9:41:44.400	32.96	34.98	12	1.6	18	29	eq	222	GII
1990321	11/17/1990	7:30:16.100	32.79	35.27	17	1.2	12	15	eq	225	GII
1990354	12/20/1990	0:02:18.500	32.55	35.25	3	1.5	10	23	eq	227	GII
1990355	12/21/1990	15:24:50.400	32.85	35.57	23	1.5	14	24	eq	228	GII
1991009	1/09/1991	2:30:42.200	32.78	35.27	20	1.1	16	19	eq	229	GII
1991026	1/26/1991	19:03:23.500	32.81	35.24	7	1.2	7	21	eq	232	GII
1991027	1/27/1991	3:05:37.100	32.82	35.28	8	1.6	7	19	eq	233	GII
1991043	2/12/1991	8:32:56.900	32.86	35.47	8	1.4	21	40	eq	235	GII
1991056	2/25/1991	6:33:55.400	32.58	35.31	21	2.0	23	41	eq	237	GII
1991095	4/05/1991	18:08:24.200	33.08	35.04	17	1.4	12	35	eq	241	GII
1991097	4/07/1991	17:18:20.100	32.84	35.59	12	1.3	11	22	eq	242	GII
1991105	4/15/1991	1:21:28.300	32.85	35.59	14	2.4	18	45	eq	243	GII
1991105	4/15/1991	5:03:50.400	32.83	35.57	4	1.5	11	22	eq	244	GII
1991106	4/16/1991	6:38:01.300	32.84	35.59	6	1.9	16	40	eq	245	GII
1991117	4/27/1991	7:13:22.800	32.84	35.62	14	1.2	8	17	eq	246	GII
1991121	5/01/1991	14:36:22.400	32.84	35.59	0	1.2	13	26	eq	247	GII
1991121	5/01/1991	20:47:12.100	32.84	35.58	6	2.2	22	55	eq	248	GII
1991123	5/03/1991	22:07:19.200	32.83	35.58	6	1.0	17	29	eq	249	GII
1991136	5/16/1991	2:50:17.200	33.08	34.98	10	1.7	18	42	eq	250	GII

GTDB: GII/Galilee Dataset: Quarry Blasts

origin time			lat	lon	dep	ml	ndef	nass	etype	evid	author
1989171	6/20/1989	10:18:50.000	32.75	35.03	0	2.6	10	51	qb	207	GII
1989312	11/08/1989	11:09:25.800	32.77	35.23	0	1.9	10	15	qb	209	GII
1990086	3/27/1990	10:37:46.000	32.78	35.38	0	1.3	10	13	qb	210	GII
1990094	4/04/1990	13:01:22.700	32.77	35.02	0	2.4	20	38	qb	211	GII
1990164	6/13/1990	7:43:04.300	32.86	35.22	0	1.7	8	8	qb	213	GII
1990204	7/23/1990	12:22:43.700	32.80	35.21	0	1.4	8	13	qb	214	GII
1990207	7/26/1990	9:57:35.400	32.80	35.20	0	1.5	5	8	qb	215	GII
1990224	8/12/1990	7:53:57.200	32.86	35.21	0	1.9	5	7	qb	217	GII
1990240	8/28/1990	14:24:46.700	32.75	35.29	0	1.7	11	15	qb	219	GII
1990254	9/11/1990	13:47:56.800	32.77	35.25	0	2.0	7	11	qb	221	GII
1990289	10/16/1990	14:05:47.500	32.76	35.03	0	2.2	11	29	qb	223	GII
1990310	11/06/1990	12:44:19.500	32.77	35.28	0	2.1	16	22	qb	224	GII
1990352	12/18/1990	12:24:12.800	32.76	35.56	0	2.2	9	15	qb	226	GII
1991009	1/09/1991	14:11:56.800	32.75	35.04	0	2.2	17	47	qb	230	GII
1991042	2/11/1991	12:55:34.800	32.76	35.54	0	2.0	18	18	qb	234	GII
1991043	2/12/1991	12:06:01.200	32.78	35.39	0	1.4	8	14	qb	236	GII
1991071	3/12/1991	11:07:40.600	32.91	35.46	0	2.0	8	17	qb	238	GII
1991076	3/17/1991	9:20:42.700	32.85	35.22	0	1.3	5	7	qb	239	GII
1991080	3/21/1991	12:08:43.300	32.78	35.39	0	1.9	17	22	qb	240	GII

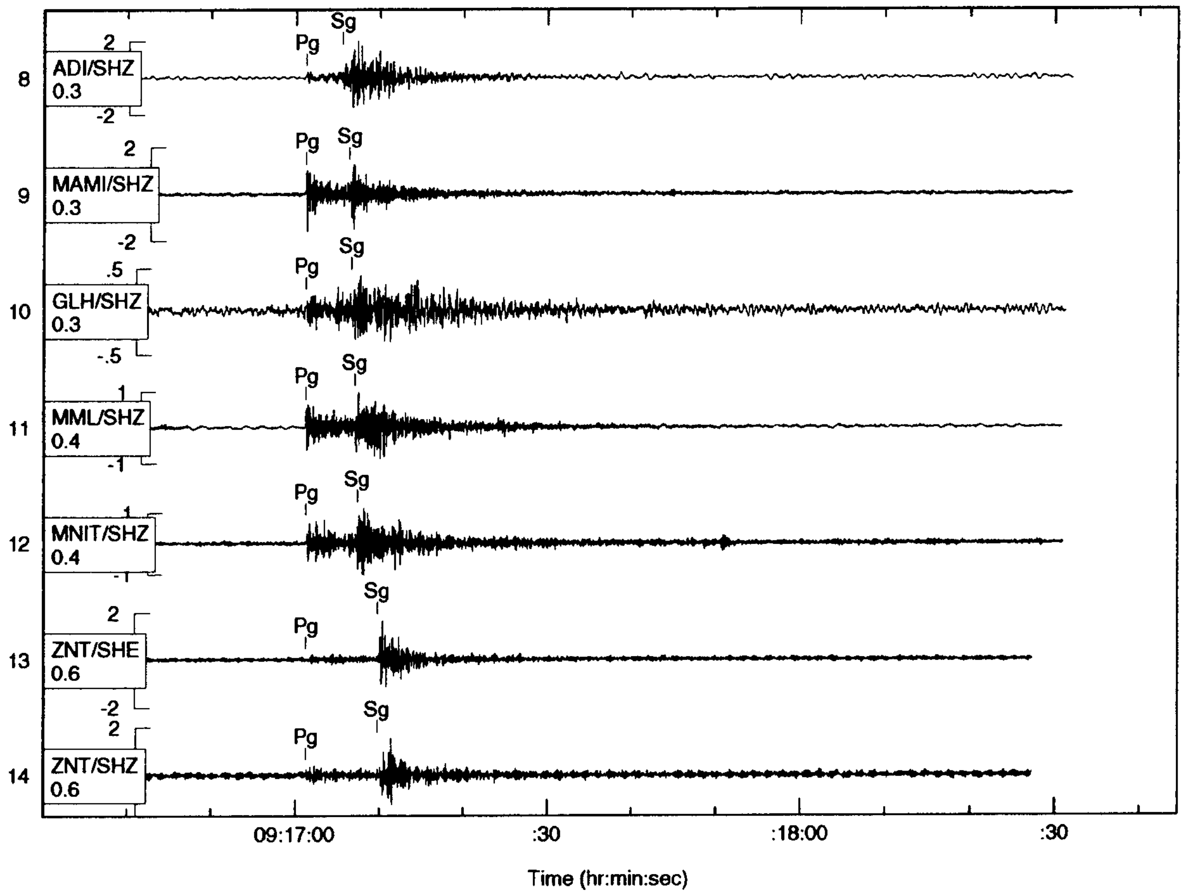
Sample Waveform Plots

Plots in this section are representative of the type of data available for events in the GII/Galilee Dataset. Five plots are shown from Event 208, an ML 1.7 earthquake with 48 associated arrivals at 25 ISN stations. Three plots are shown from Event 211, an ML 2.4 quarry blast with 38 associated phases at 20 ISN stations. This event was generated by a 15 ton blast at the Carmel mine.



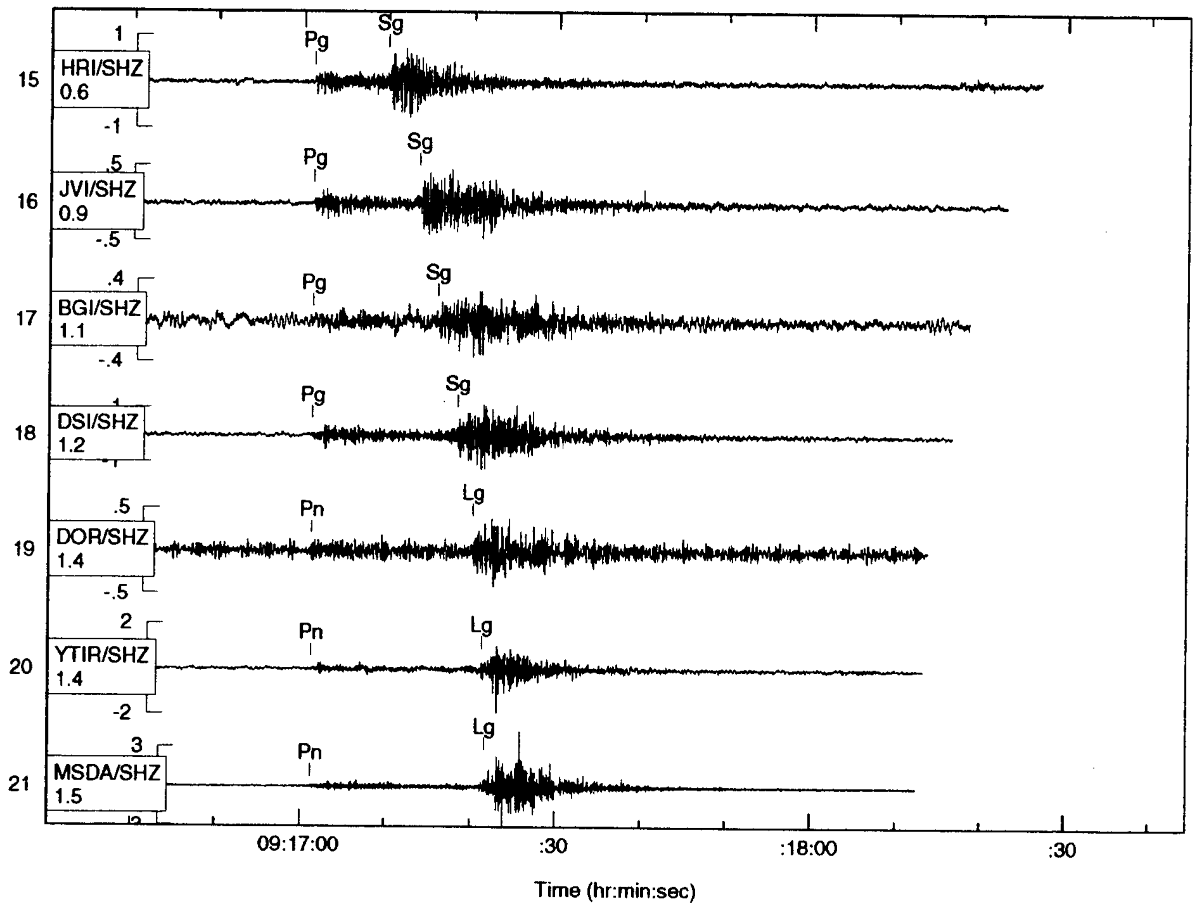
Time scale: six units = one minute.

Figure 30: Event 208 plotted at ranges of less than 0.1 to 0.3 degrees. Unfiltered.



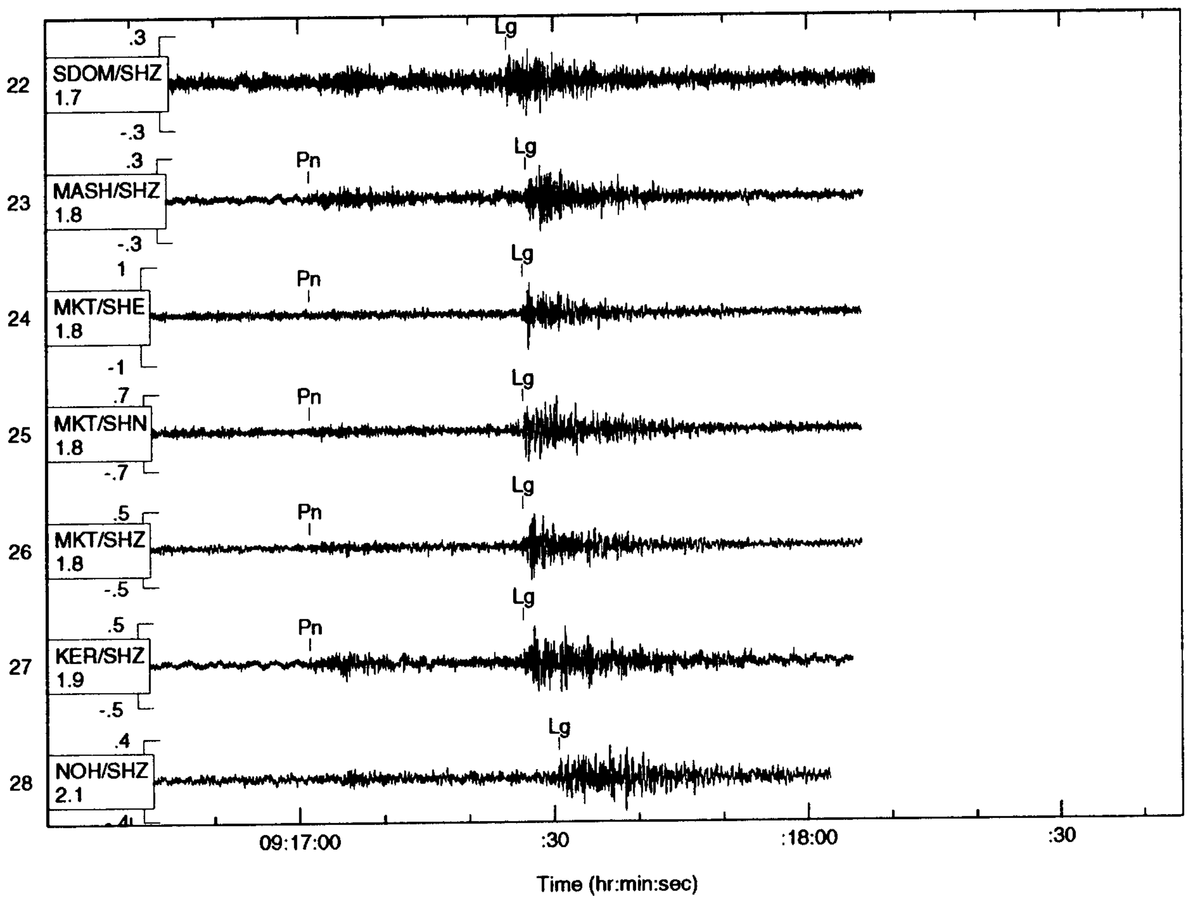
Time scale: six units = one minute.

Figure 31: Event 208 plotted at ranges 0.3 to 0.6 degrees. Unfiltered.



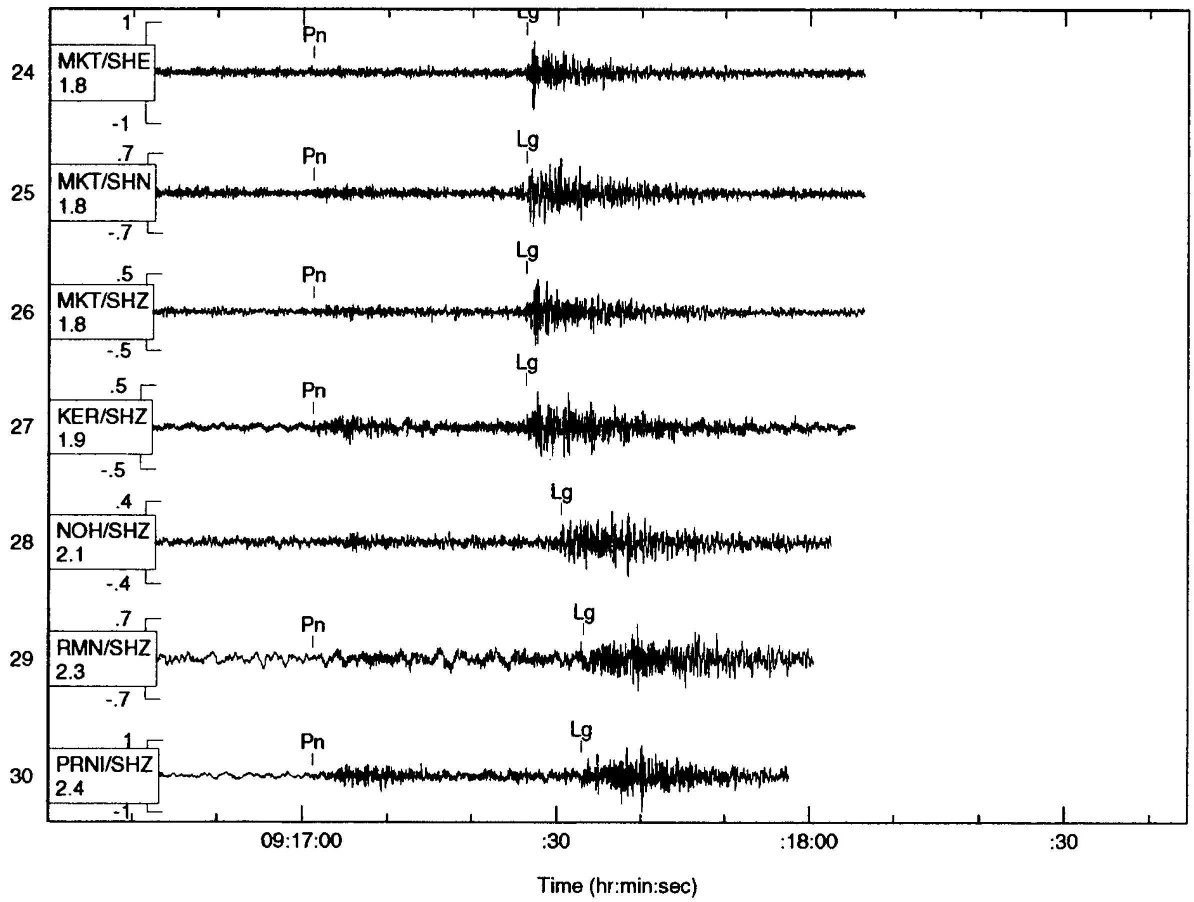
Time scale: six units = one minute.

Figure 32: Event 208 plotted at ranges 0.6 to 1.5 degrees. Unfiltered.



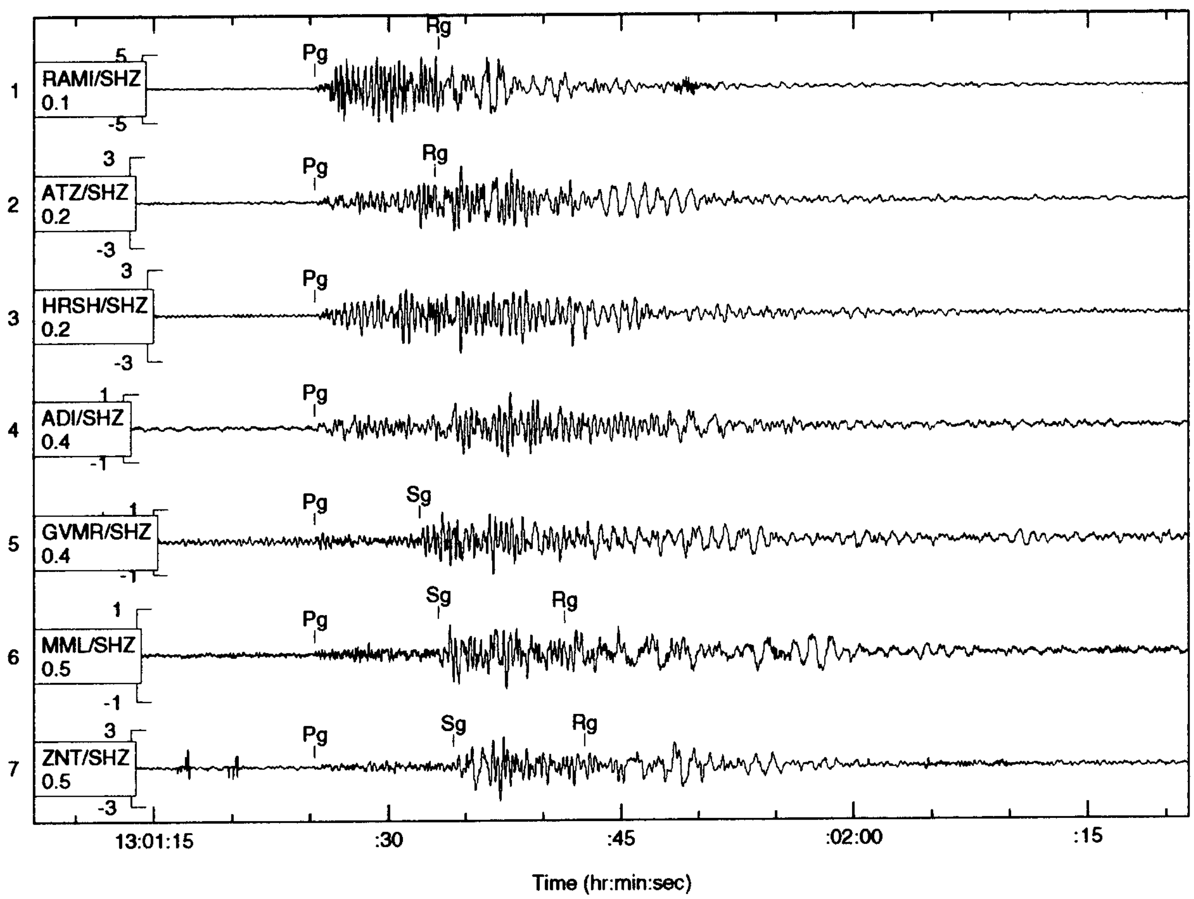
Time scale: six units = one minute.

Figure 33: Event 208 plotted at ranges 1.7 to 2.1 degrees. Unfiltered.



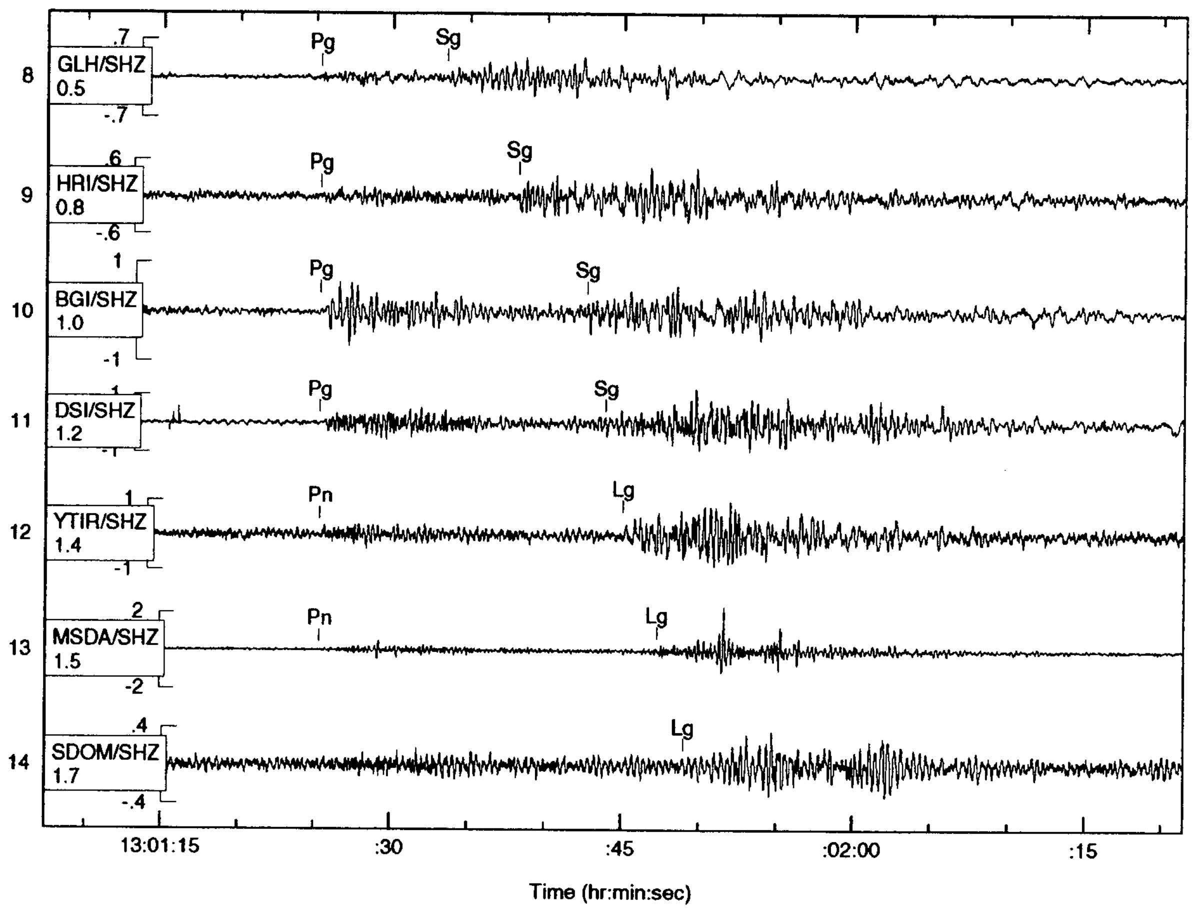
Time scale: six units = one minute.

Figure 34: Event 208 plotted at ranges 1.8 to 2.4 degrees. Unfiltered.



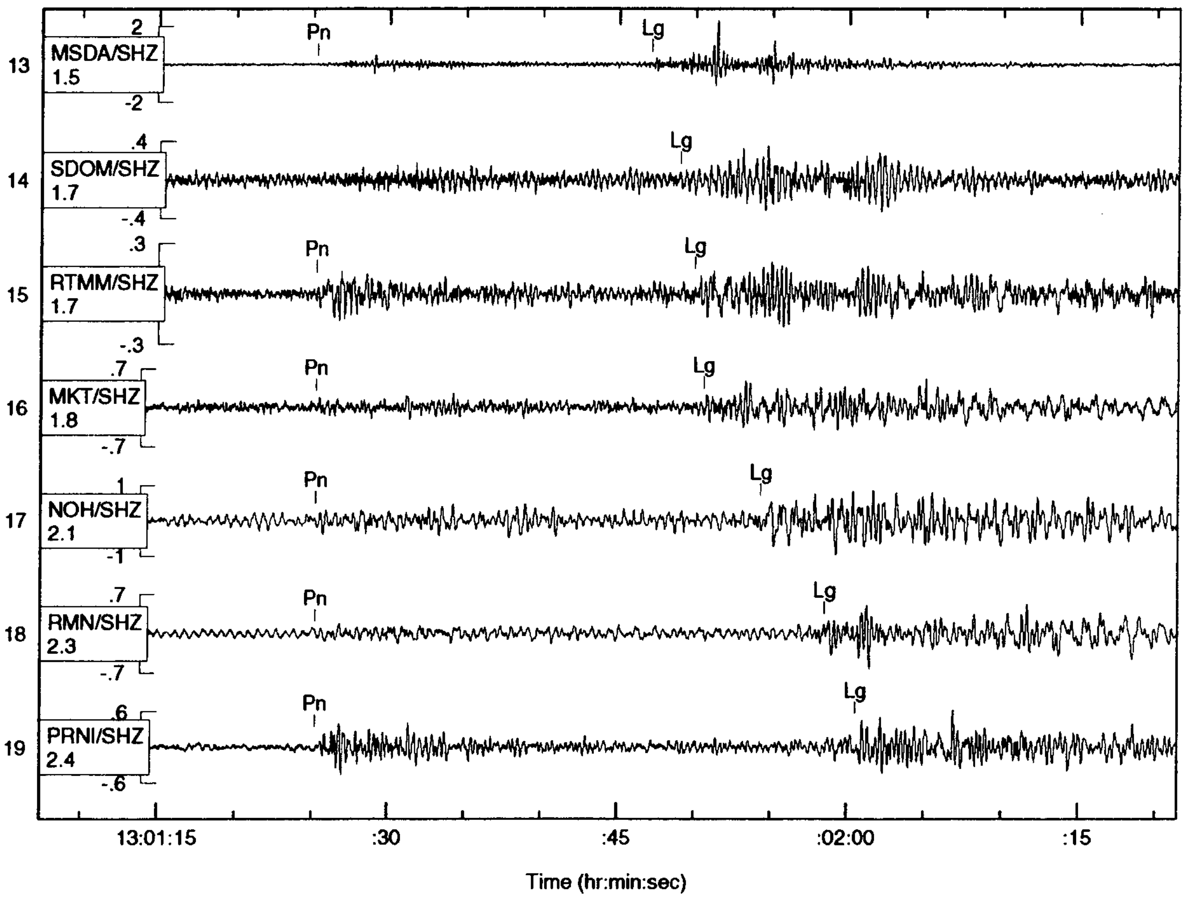
Time scale: twelve units = one minute.

Figure 35: Event 211 plotted at ranges 0.1 to 0.5 degrees. Unfiltered.



Time scale: twelve units = one minute.

Figure 36: Event 211 plotted at ranges 0.5 to 1.7 degrees. Unfiltered.



Time scale: twelve units = one minute.

Figure 37: Event 211 plotted at ranges 1.5 to 2.4 degrees. Unfiltered.

Chapter 5

The JSOP-I and JSOP-II Datasets

The purpose of compiling the two datasets described in this chapter was to take advantage of the bulletins resulting from the experiments known as the Joint Seismic Observation Program (JSOP). These experiments were undertaken to improve earthquake monitoring capabilities in the Eastern Mediterranean Region through cooperation between the seismological institutions operating in the region. The goals were to have each participating institution report each earthquake of magnitude 3.0 or above to all other participating institutions.

The European-Mediterranean Seismological Centre[29] (EMSC) acts as the data center for JSOP experiments: phase readings are exchanged between participants and the bulletins are produced and distributed. Waveform data are not exchanged as part of the JSOP experiments. The bulletins we used to build the JSOP-I and JSOP-II datasets were obtained from EMSC's anonymous FTP site[30] in France.

The JSOP-I experiment was conducted between September and November of 1994. Participants in the first experimental period (JSOP-I) included institutions located in: Cyprus, Egypt, Israel, Jordan, Lebanon, Saudi Arabia, Turkey, and Yemen. Shapira summarizes the experiment in EMSC Newsletter No. 8 (EMSC, 1995).

Syria joined for JSOP-II, which began in January of 1996. At the time we compiled the JSOP-II datset, the experiment was on-going. The JSOP-II dataset is based on bulletins from only the first quarter of 1996.

We had hoped to use the JSOP bulletins as a guide to segmenting waveforms from the the IRIS database for events which were smaller than those available in the global bulletins (*e.g.* REB, USGS). The method proved unuseful. Only a few of the events listed in the JSOP bulletins were large enough to register on available IRIS stations. The JSOP bulletins may prove useful in the future if waveforms are distributed with the seismic bulletins or are otherwise available from the observing institutions.

[29]Read more about EMSC's charter at URL: http://www.gsrg.nmh.ac.uk/esc/emsc.html

[30]URL: ftp:/ldg.bruyeres.cea.fr

We selected events from the JSOP-I bulletin which were re-located by EMSC using all available arrivals contributed by participating institutions. Participating networks are as follows:

- IL - IPRG[31], Israel
- KSU - King Saud University, Saudi Arabia
- KAN - Kandilli Observatory and Earthquake Research Institute., Turkey
- YEME- Seismological Observatory, Yemen
- JOR - NRA, Jordan
- EGYP- NRIAG, Egypt
- LIB - National Council for Scientific Research, Lebanon
- CYPR- Geological Survey Department, Cyprus
- GEB - Marmara Research Centre, Turkey
- EMSC- Location from the EMSC (utilizing all arrival times available)

Of the 70 events in the JSOP-I bulletin, about 35 events were listed with EMSC as author. For these, we requested data from the IRIS database for stations ANTO, ABKT, KEG, and BGIO. We requested segments of 8 minutes length starting 2 minutes before the first expected P arrival.

The events were grouped into 3 geograpic regions for interactive waveform analysis. Careful review of all available waveforms from the four stations listed above resulted in a total of 85 phases being associated with 24 of the events. About one-half of these were located in the Gulf of Aqaba. We did not retain in the dataset, any events that did not have at least one associated arrival. The resulting dataset is shown in Figure 38.

No arrivals were assocated from station ANTO. Station ABKT contributed 8 arrivals to 3 events in Region 2. Station KEG has 30 arrivals associated with 14 events. Station BGIO has the largest number of associated arrivals: 47. Sample waveform plots are shown in Figures 39 through 45.

The event locations in the JSOP-I bulletin were compared with those in the Earthquake Data Reports (EDR) published by the USGS/NEIC. Of the 24 events comprising this dataset, 21 were published in the EDR. All but 4 of these had location differences of less than 100 km. Five of these are labeled as "eq" based on the USGS's EDR. Others are of unknown event type.

[31] Formerly the Institute for Petroleum Research and Geophysics, it is now called the Geophysical Institute of Israel.

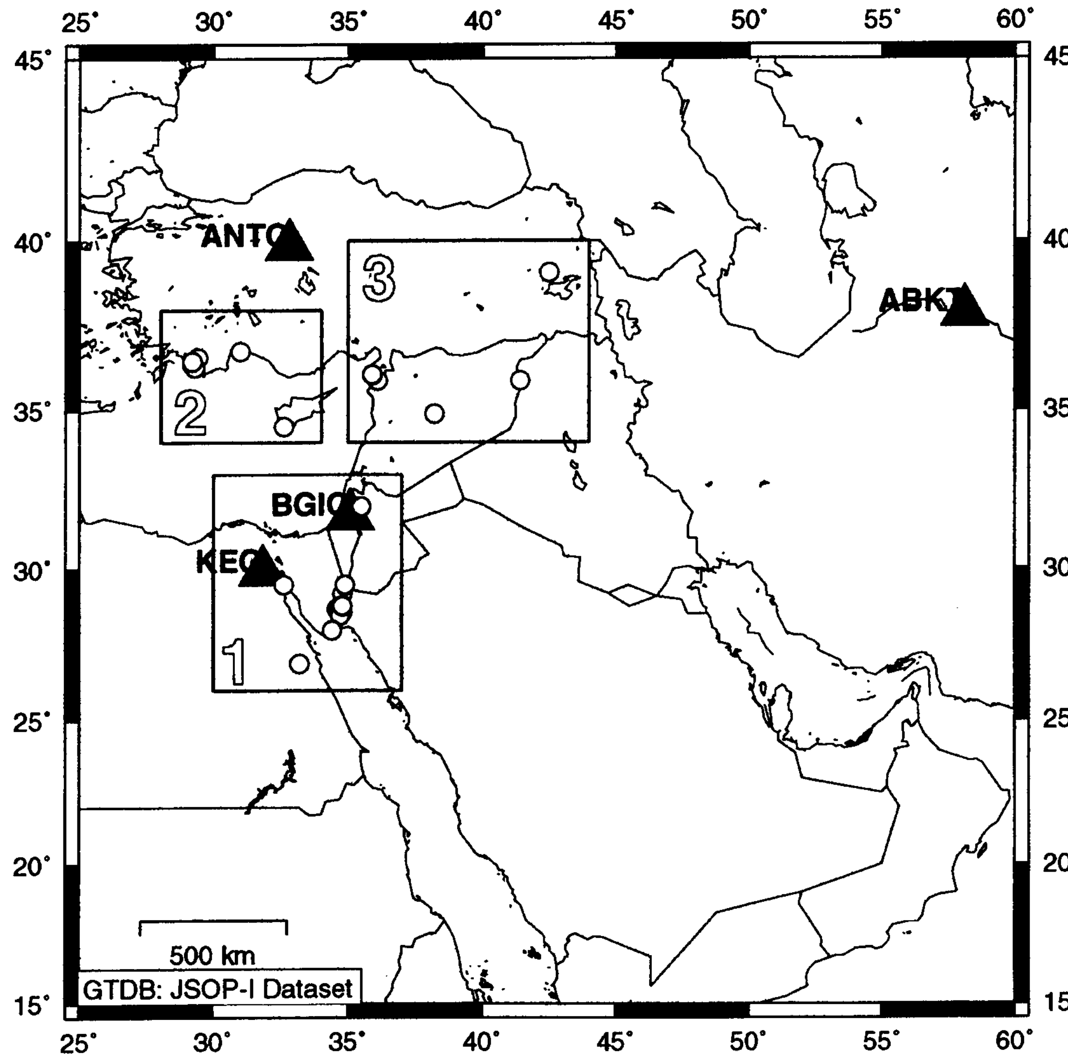


Figure 38: The JSOP-I dataset. Waveforms were retrieved from the IRIS DMC archives for 35 events listed in the JSOP-I bulletin with EMSC as author. Interactive waveform analysis resulted in phases being associated with the 24 events shown in the map. One-half of these events are located near the Gulf of Aqaba. The JSOP-I experiment was conducted between September and November of 1994.

Event Lists

In the event listings below, the origin time, latitude, longitude, depth, and mb are defined by the EMSC after relocating events based on arrival information sent to EMSC by institutions participating in the JSOP-I experiment.

GTDB: JSOP-I Dataset: Event List: Region 1

origin time			lat	lon	dep	d	ml	ndef	nass	etype	evid	author
1994244	9/01/1994	4:07:31.400	29.20	34.80	2	-	3.2	28	4	u	251	EMSC
1994259	9/16/1994	3:18:57.200	32.00	35.50	6	-	4.1	44	6	eq	255	EMSC
1994265	9/22/1994	12:39:13.400	28.70	34.60	3	-	3.1	29	5	u	258	EMSC
1994268	9/25/1994	6:08:07.500	28.70	34.70	2	-	2.4	28	1	u	259	EMSC
1994269	9/26/1994	17:27:00.800	26.90	33.20	2	-	4.0	27	7	u	260	EMSC
1994271	9/28/1994	9:38:42.000	29.50	32.60	2	-	3.9	37	7	u	262	EMSC
1994271	9/28/1994	12:03:15.800	28.70	34.70	10	-	2.7	13	1	u	263	EMSC
1994292	10/19/1994	14:25:53.000	28.60	34.70	2	-	2.3	17	1	u	267	EMSC
1994292	10/19/1994	14:36:10.300	28.60	34.80	2	-	2.2	8	1	u	268	EMSC
1994308	11/04/1994	10:54:03.300	28.50	34.70	2	-	3.8	27	2	u	278	EMSC
1994310	11/06/1994	1:46:13.200	28.00	34.40	3	-	3.5	12	1	u	280	EMSC
1994311	11/07/1994	12:59:43.200	29.50	34.90	24	-	3.5	22	2	u	281	EMSC
1994318	11/14/1994	18:23:25.500	28.80	34.80	2	-	3.7	31	3	u	285	EMSC

GTDB: JSOP-I Dataset: Event List: Region 2

origin time			lat	lon	dep	d	ml	ndef	nass	etype	evid	author
1994252	9/09/1994	7:40:17.300	34.50	32.60	2	-	2.7	29	3	u	252	EMSC
1994256	9/13/1994	1:00:43.000	36.80	31.00	2	-	3.5	40	4	u	254	EMSC
1994308	11/04/1994	21:18:27.900	36.60	29.40	30	-	4.2	46	2	u	279	EMSC
1994317	11/13/1994	6:56:11.100	36.40	29.20	2	-	4.6	57	6	eq	282	EMSC
1994317	11/13/1994	7:13:55.700	36.30	29.30	2	-	4.3	52	3	eq	283	EMSC
1994317	11/13/1994	8:15:30.900	36.50	29.20	2	-	4.9	54	6	eq	284	EMSC

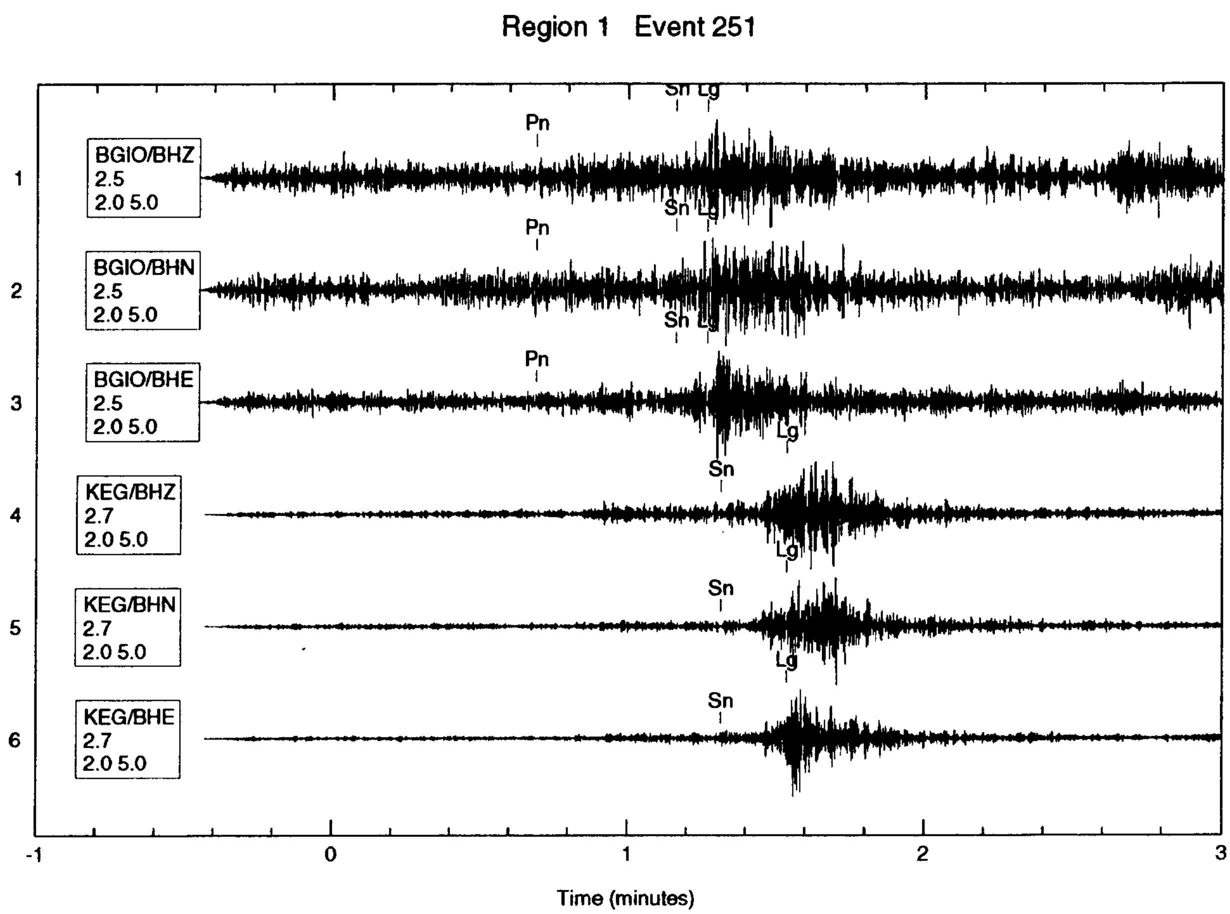
GTDB: JSOP-I Dataset: Event List: Region 3

origin time			lat	lon	dep	d	ml	ndef	nass	etype	evid	author
1994254	9/11/1994	23:33:57.300	35.90	36.10	2	-	3.3	32	4	u	253	EMSC
1994260	9/17/1994	2:24:25.500	39.10	42.50	2	-	5.7	72	3	eq	256	EMSC
1994261	9/18/1994	20:24:47.800	36.10	35.90	5	-	-9.0	15	4	u	257	EMSC
1994279	10/06/1994	21:10:45.600	34.90	38.20	26	-	3.9	29	4	u	264	EMSC
1994324	11/20/1994	14:30:44.700	35.90	41.40	2	-	6.1	59	5	u	286	EMSC

Sample Waveform Plots

Plots in this section are representative of the data available for events in the JSOP-I Dataset. Several plots are shown from each region.

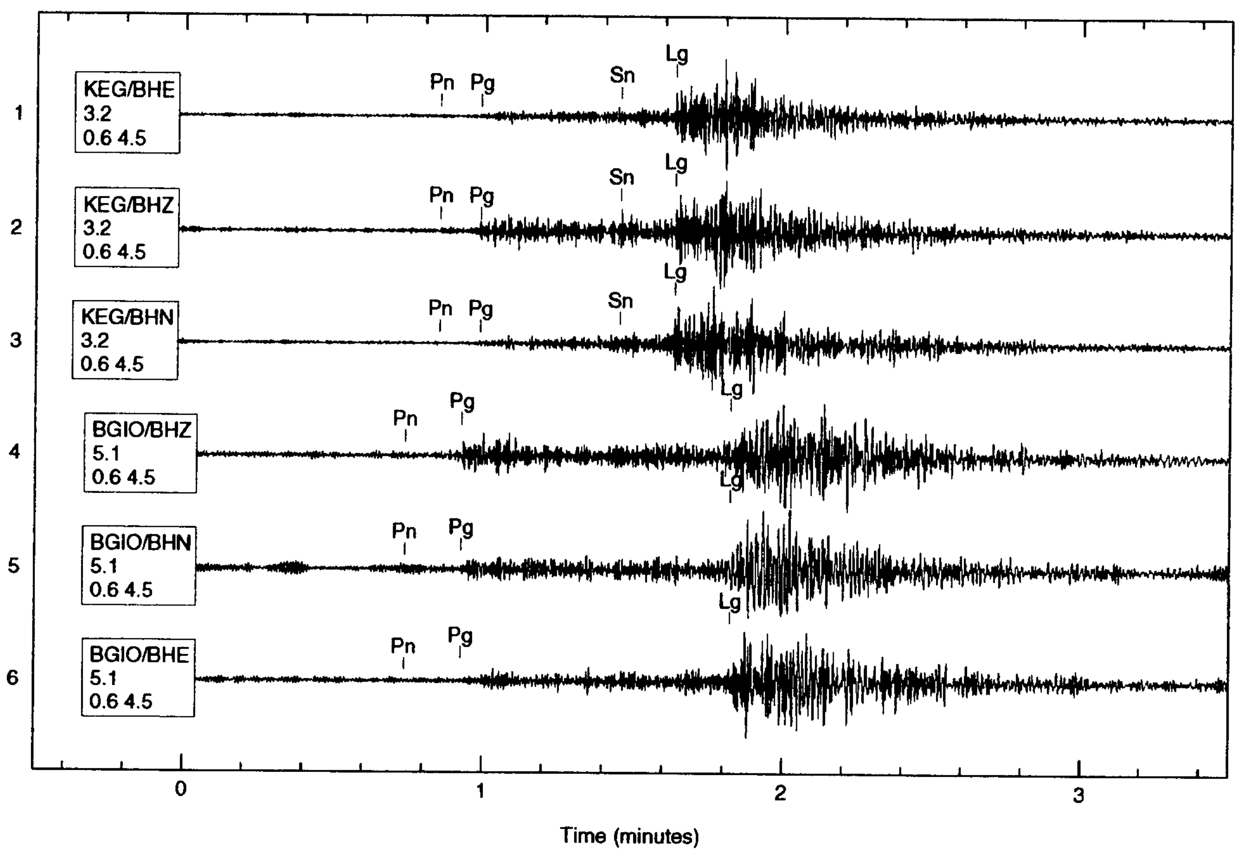
Time scales, which vary from plot to plot, are explained below each plot. Traces are aligned on the theoretical first arrival. Traces are usually shown after filtering with causal bandpass filters. The waveform tags list station/channel, event-to-station distance (degrees), and filter corners (low, high). Independent vertical scaling was applied to the traces.



Time scale: five units = one minute.

Figure 39: Event 251 from Region 1. This is one of the events located in the Gulf of Aqaba.

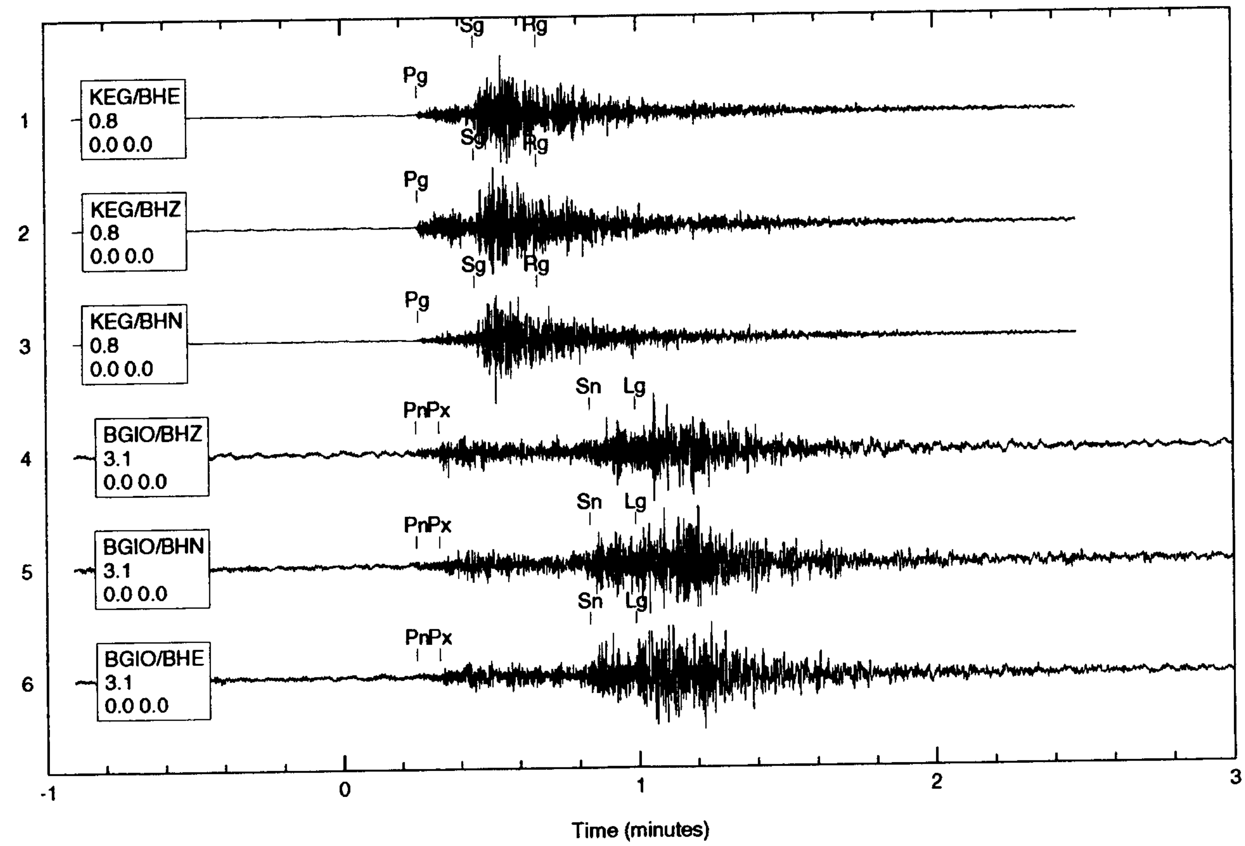
Region 1 Event 260



Time scale: five units = one minute.

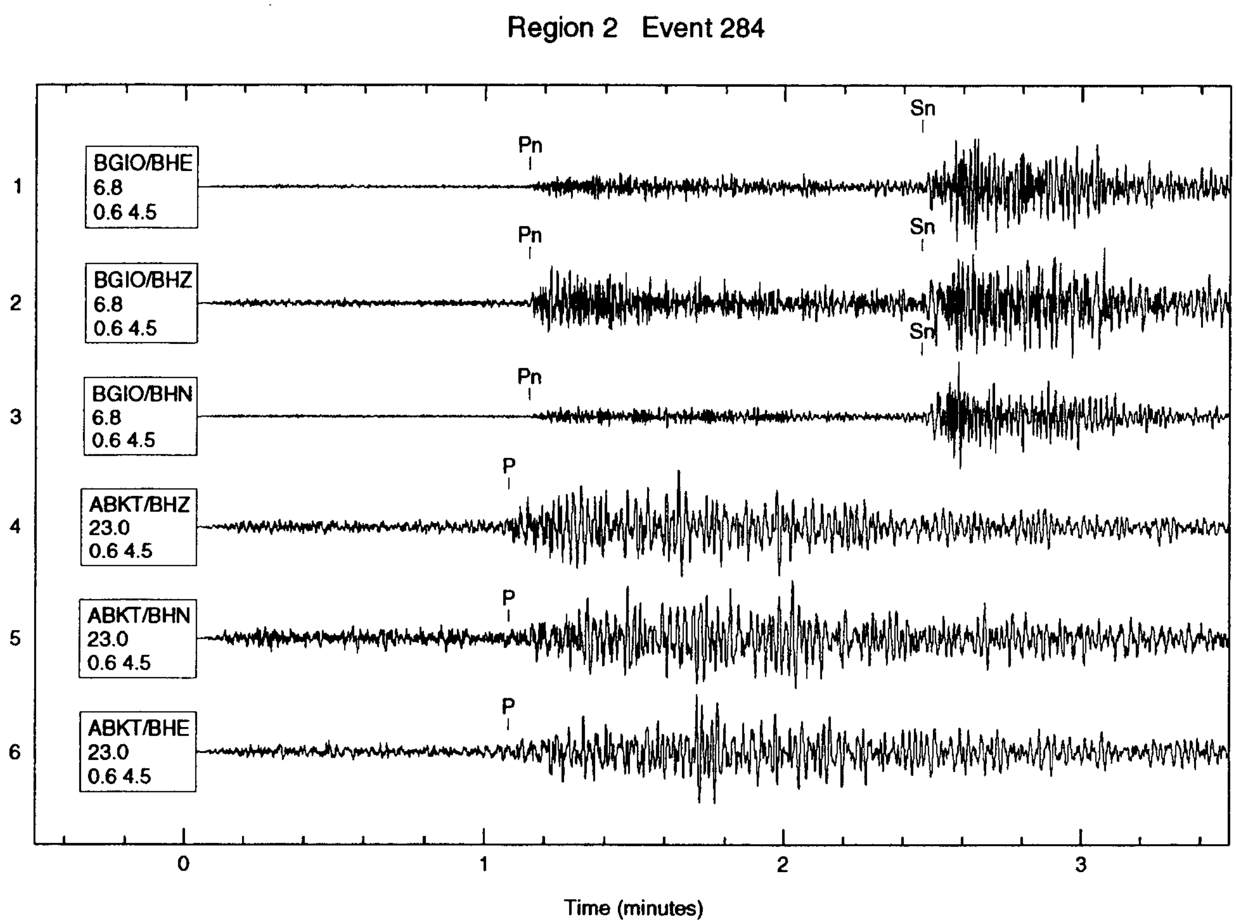
Figure 40: Event 260 from Region 1. This event is located in Egypt. Traces are aligned on theoretical Pn arrival, indicating there is a location error.

Region 1 Event 262



Time scale: five units = one minute.

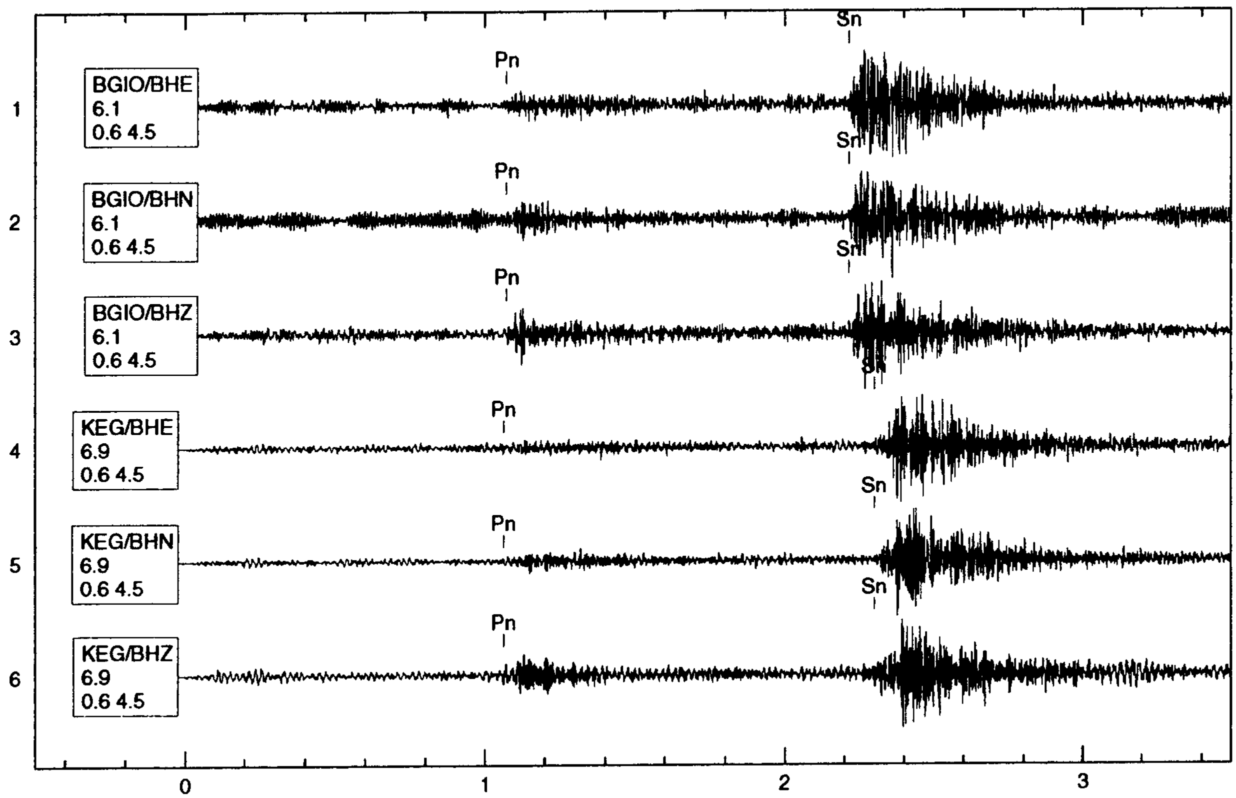
Figure 41: Event 262 from Region 1. This event is located near KEG.



Time scale: five units = one minute.

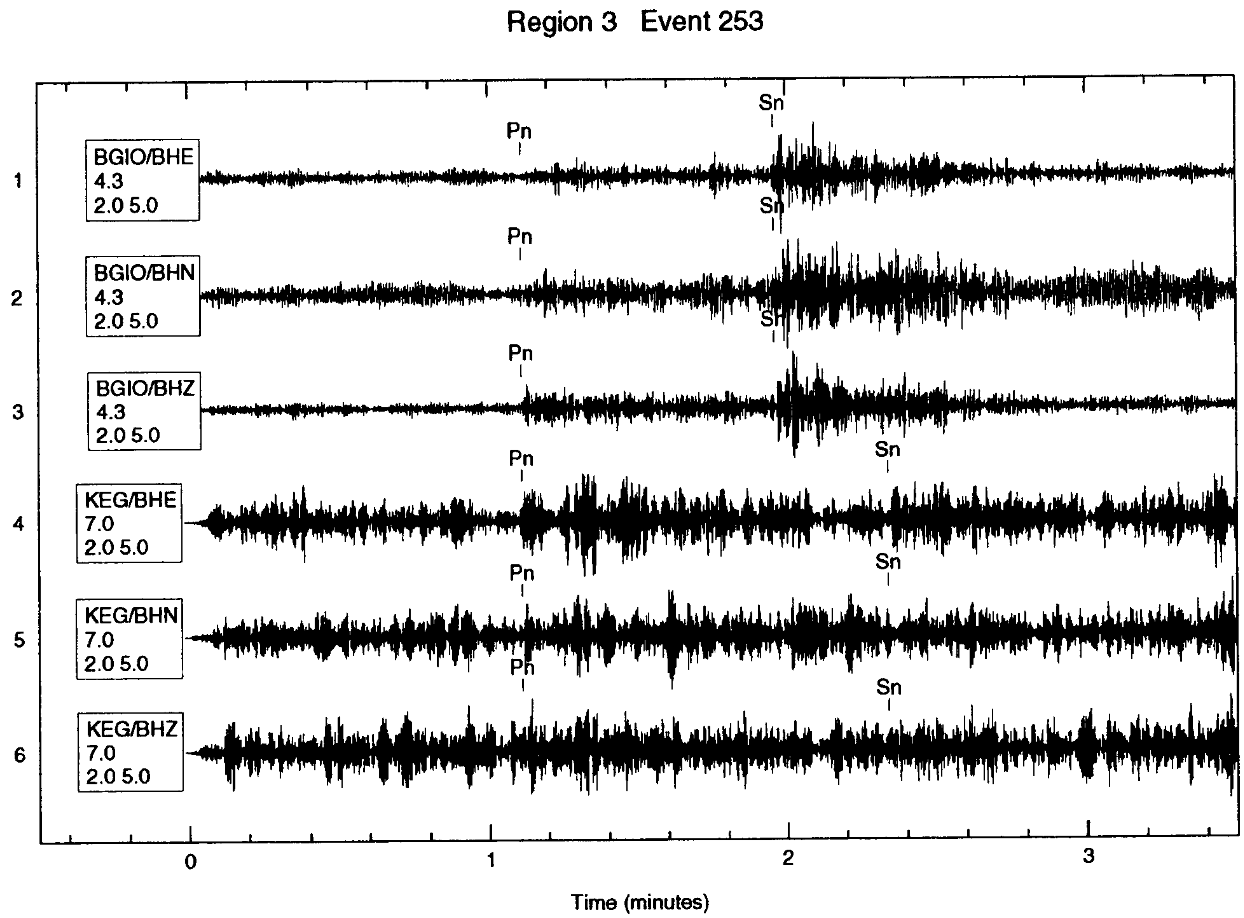
Figure 42: Event 284 from Region 2. This event is representative of the cluster near Mugla, Turkey, which records Pn and Sn at BGIO and P at ABKT.

Region 2 Event 254



Time scale: five units = one minute.

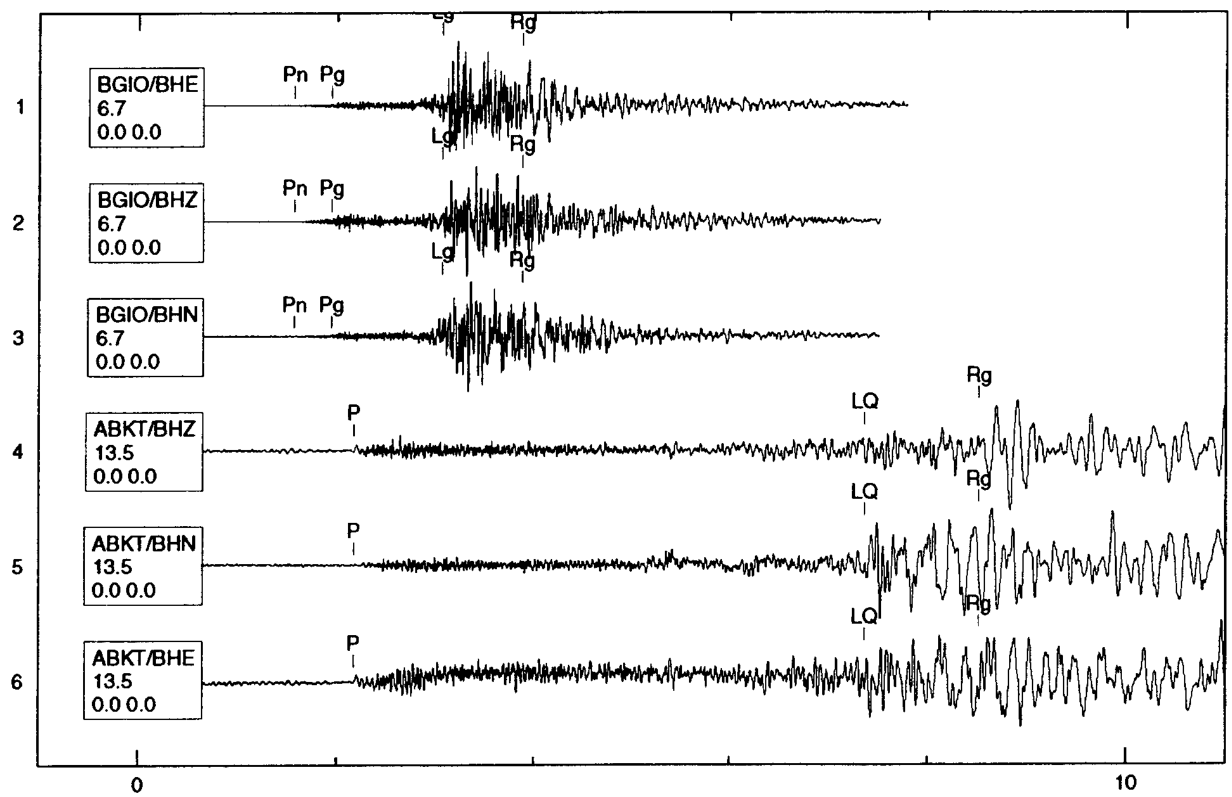
Figure 43: Event 254 from Region 2. This event, east of the Mugla group, records Pn and Sn at both KEG and BGIO.



Time scale: five units = one minute.

Figure 44: Event 253 from Region 3. This is one of the two events located near the coast which records Pn and Sn at KEG and BGIO.

Region 3 Event 286



Time scale: one unit = two minutes.

Figure 45: Event 286 from Region 2. This is one of the events in eastern Syria which records Pn and Lg at BGIO.

At the time we compiled the JSOP-II dataset in March 1997, the JSOP-II experiment was on-going. We obtained only the bulletins from the first quarter of 1996. A program, jsop2css, written by Ivan Henson was used to convert from the JSOP format to CSS3.0 format. Resulting tables were *arrival, assoc, origin, and remark.* There were 7,822 lines in the *arrival* and *assoc* tables resulting from this conversion, although we ultimately used only the *origin* and *remark* tables.

EMSC did not do locations in the JSOP-II experiment as they had done in JSOP-I. The author of the events is the institution who contributed the event hypocenters. Out of 1,230 events in the first quarter of 1996, over 1,100 were aftershocks of the Ms 7.1 Gulf of Aqaba event of November 22, 1995. Because this aftershock series is represented in the Saudi dataset[32], we collected data only for the 58 events located outside the Gulf of Aqaba. Of these, 46 were contributed by Syria and 12 were contributed by other countries as follows: SYR(46); IL(2); KAN(9); KSU(1).

From the IRIS database, we requested data from stations ANTO, KIV, ABKT, AAE plus all stations from the temporary Saudi network (Vernon *et al.*, 1996). Careful review of all available waveforms resulted in the association of 105 arrivals with 13 events. Most of the 58 events reviewed were too small to be observed on stations from the IRIS archives due to their small magnitudes and lack of near regional data available.

Only the 13 events with at least one associated arrival were retained in the database. Station ANTO has the largest number of associated arrivals as shown below. Stations in the Saudi network are the last five listed.

	phases	events
AAE	3	1
ABKT	3	2
ANTO	21	7
KIV	9	5
AFIF	9	4
HALM	18	9
RANI	15	9
RAYN	16	6
SODA	11	8

All of the events in this dataset are labeled as earthquake based on remarks in the JSOP-II bulletin. Several events were reported as "felt" earthquakes in the USGS bulletins.

[32]The Saudi dataset is described in Chapter 6, beginning on page 103 of this report.

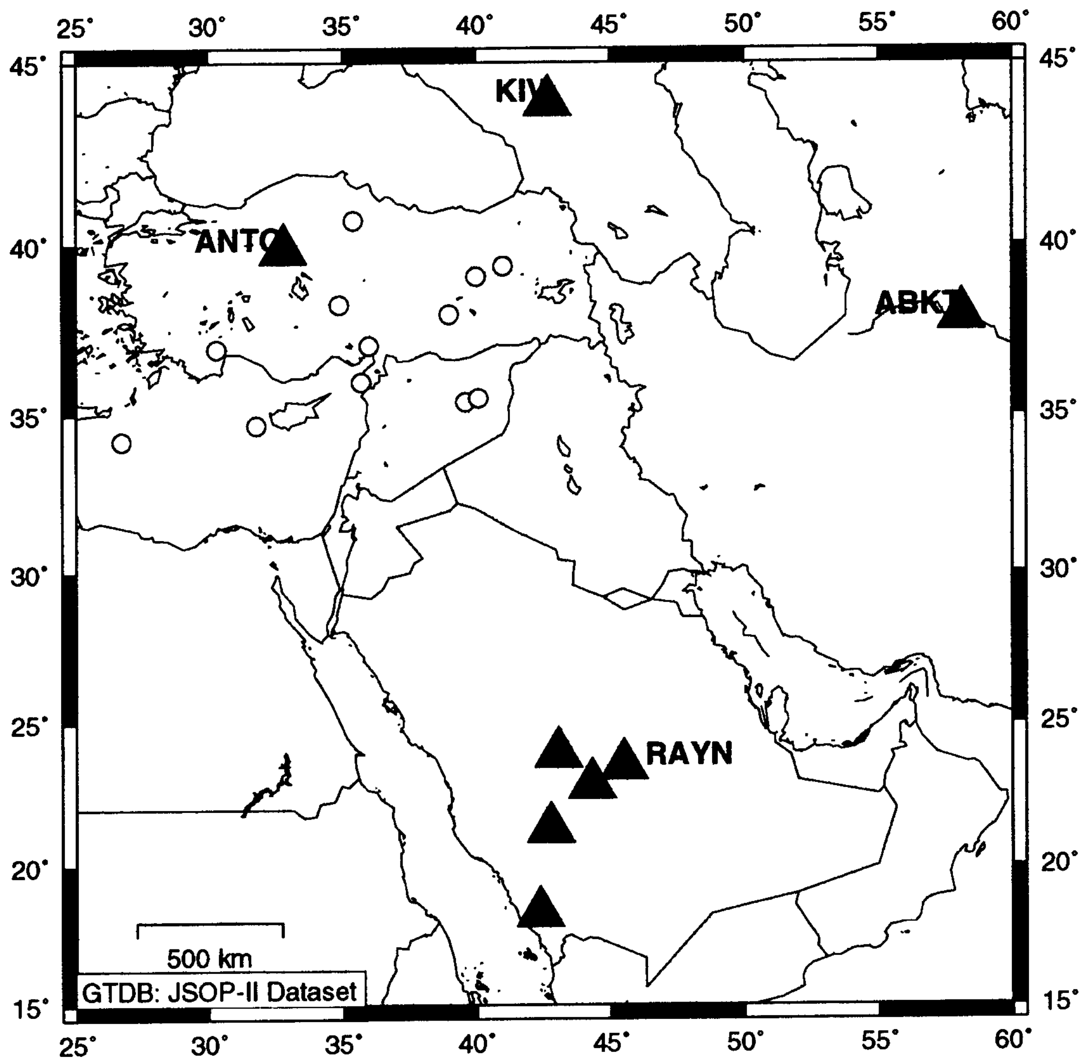


Figure 46: The JSOP-II dataset. This dataset was compiled from the JSOP-II bulletin covering the first quarter of 1996. We did not include events related to the 1995 Gulf of Aqaba sequence. The 24 events shown on the map have at least one associated phase in the GTDB.

Event Lists

In the event listing below, the origin time, latitude, longitude, depth are defined by the institution listed in the author field. In the JSOP-II event list, ndef refers to the number of arrivals listed for the event in the JSOP-II bulletin. For some of the events, additional hypocenters were contributed for the same event by other institutions. This additional information along with Coda Magnitudes (Mc) contributed by SYR, is listed in the *remark* table.

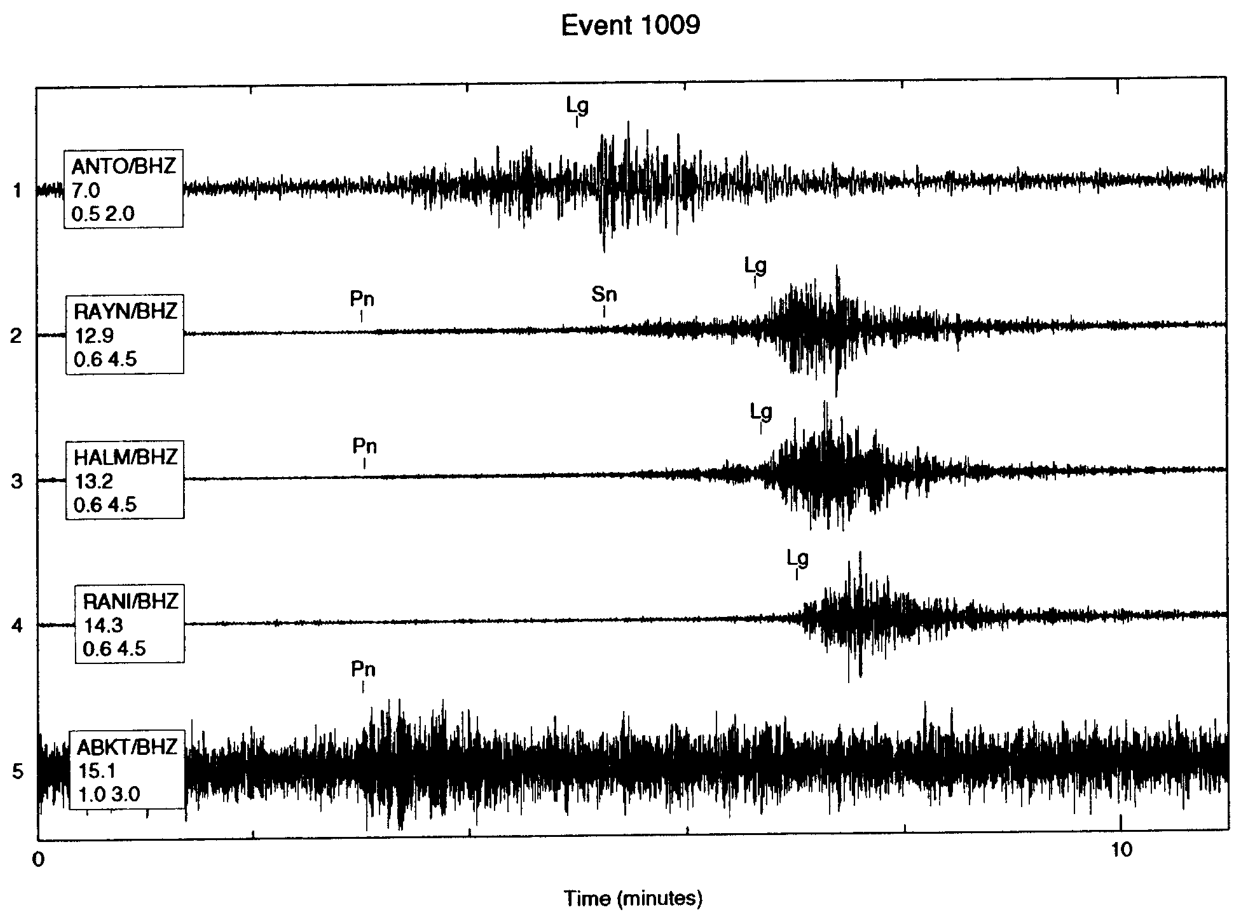
GTDB: JSOP-II Dataset: Event List

origin time			lat	lon	dep	d	mb	ndef	nass	etype	evid	author
1996004	1/04/1996	15:28:36.640	35.40	39.60	6	-	-9.0	18	12	eq	1004	JSOP:SYR
1996011	1/11/1996	23:03:48.660	35.40	39.60	15	-	-9.0	11	9	eq	1009	JSOP:SYR
1996021	1/21/1996	9:28:41.980	36.00	35.70	20	-	-9.0	42	2	eq	1014	JSOP:SYR
1996021	1/21/1996	13:00:24.360	35.50	40.10	11	-	-9.0	16	6	eq	1015	JSOP:SYR
1996040	2/09/1996	22:47:59.559	34.69	31.80	40	-	-9.0	12	15	eq	1022	JSOP:SYR
1996061	3/01/1996	6:48:57.850	34.20	26.70	15	-	-9.0	18	17	eq	1038	JSOP:SYR
1996014	1/14/1996	15:18:17.000	39.10	40.00	13	-	0.0	5	1	eq	1045	JSOP:KAN
1996038	2/07/1996	12:27:00.340	38.00	39.00	15	-	0.0	7	22	eq	1048	JSOP:KAN
1996063	3/03/1996	22:52:21.100	38.30	34.90	0	-	0.0	4	2	eq	1051	JSOP:KAN
1996068	3/08/1996	17:30:15.900	39.40	41.00	9	-	0.0	5	1	eq	1052	JSOP:KAN
1996076	3/16/1996	14:36:23.800	37.00	30.30	19	-	0.0	16	17	eq	1054	JSOP:KAN
1996077	3/17/1996	14:12:57.500	40.70	35.40	4	-	0.0	9	12	eq	1055	JSOP:KAN
1996080	3/20/1996	11:48:42.300	37.10	36.00	0	-	0.0	8	12	eq	1056	JSOP:KAN

Sample Waveform Plots

Plots in this section are representative of the data available for events in the JSOP-II dataset.

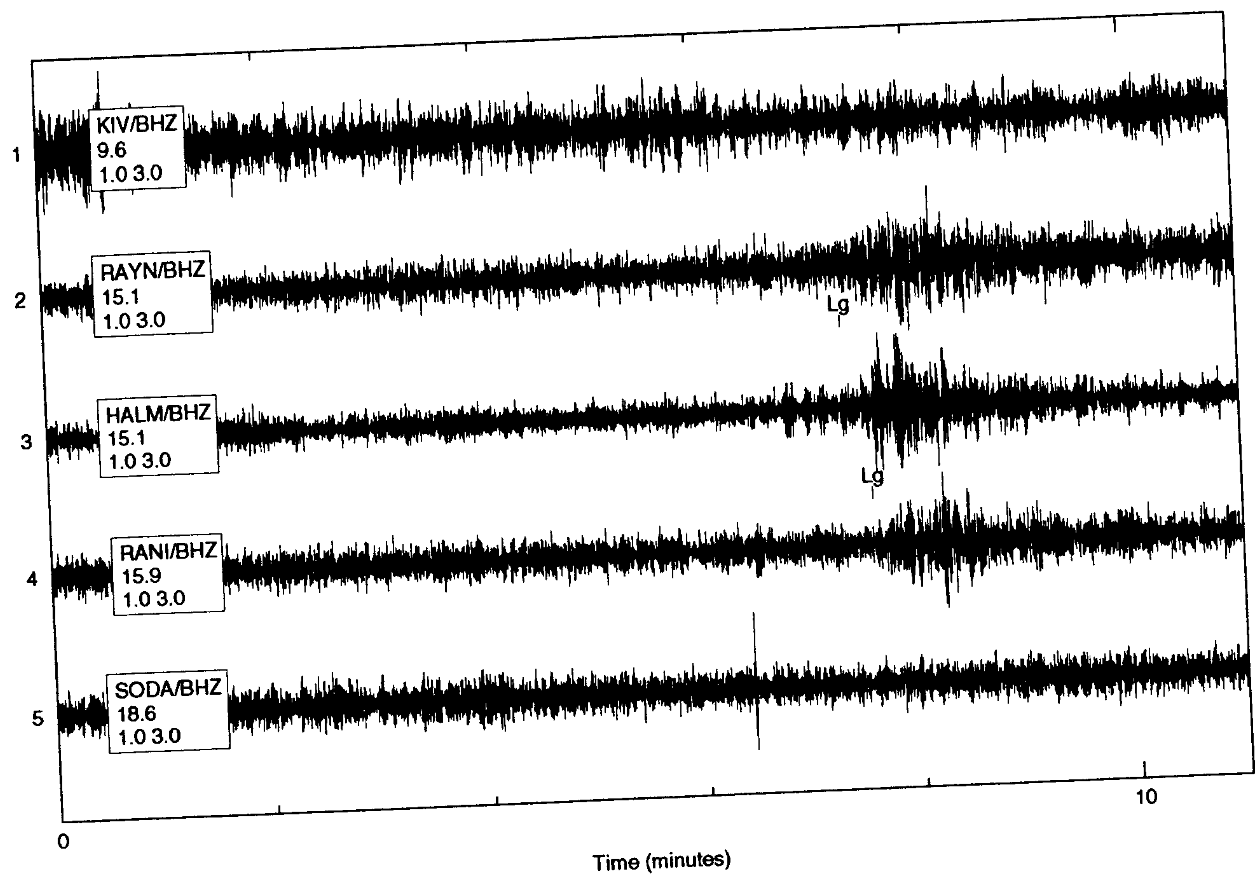
Time scales, which vary from plot to plot, are explained below each plot. Traces are aligned on the theoretical first arrival. Traces are usually shown after filtering with causal bandpass filters. The waveform tags list station/channel, event-to-station distance (degrees), and filter corners (low, high). Independent vertical scaling was applied to the traces.



Time scale: one unit = two minutes.

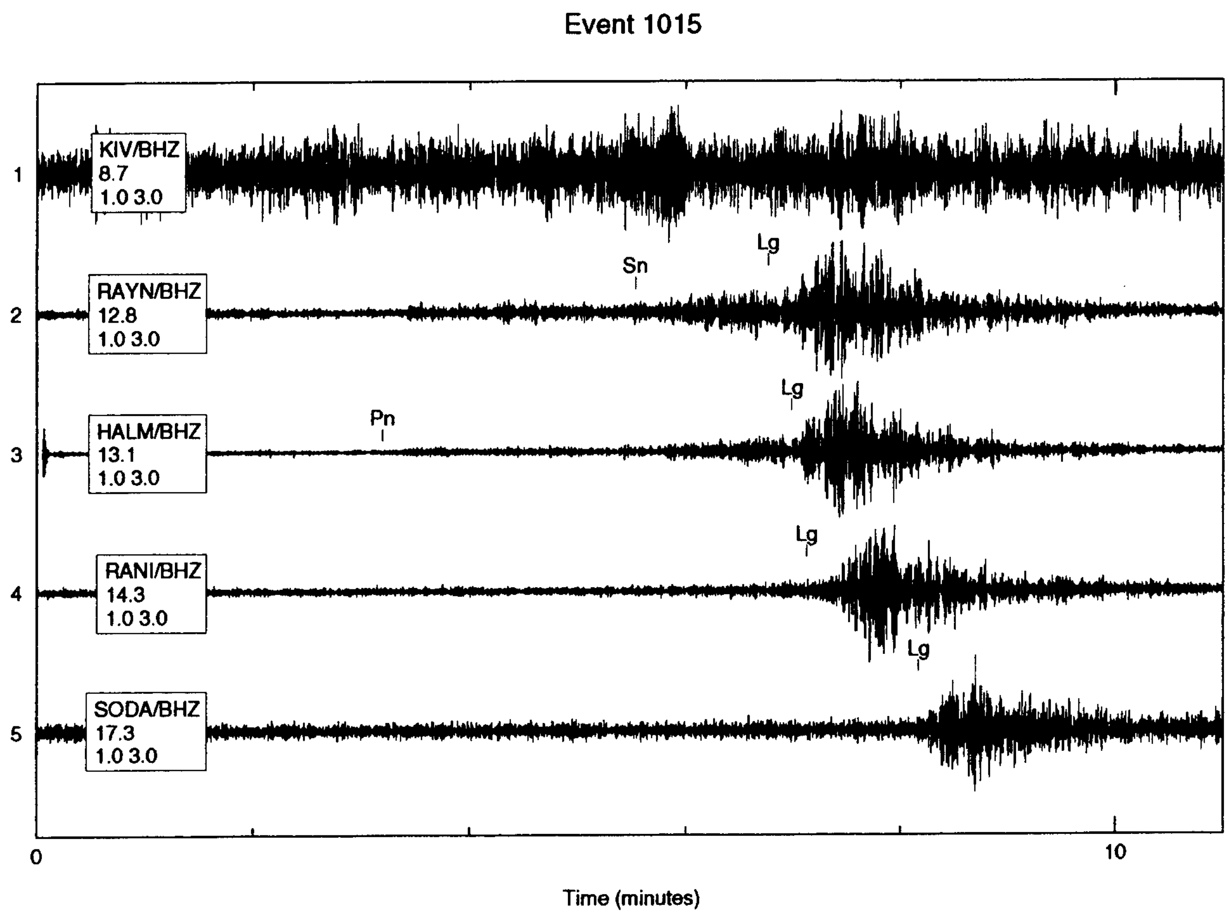
Figure 47: Event 1009. This Syrian event records well on the temporary Saudi network.

Event 1014



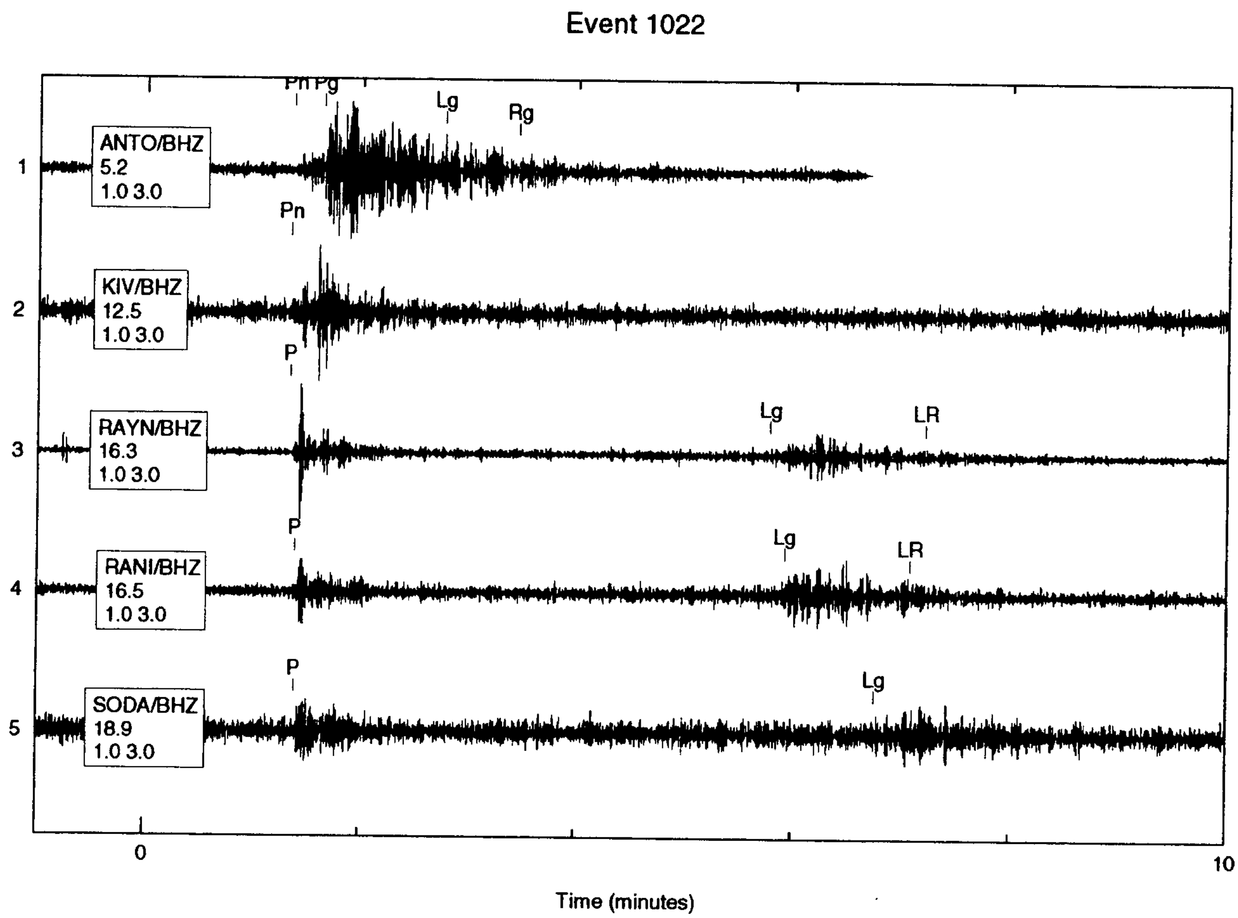
Time scale: one unit = two minutes.

Figure 48: Event 1014. This event is located off the coast of Syria and was listed in the USGS bulletin with a magnitude of 3.3 Mb..



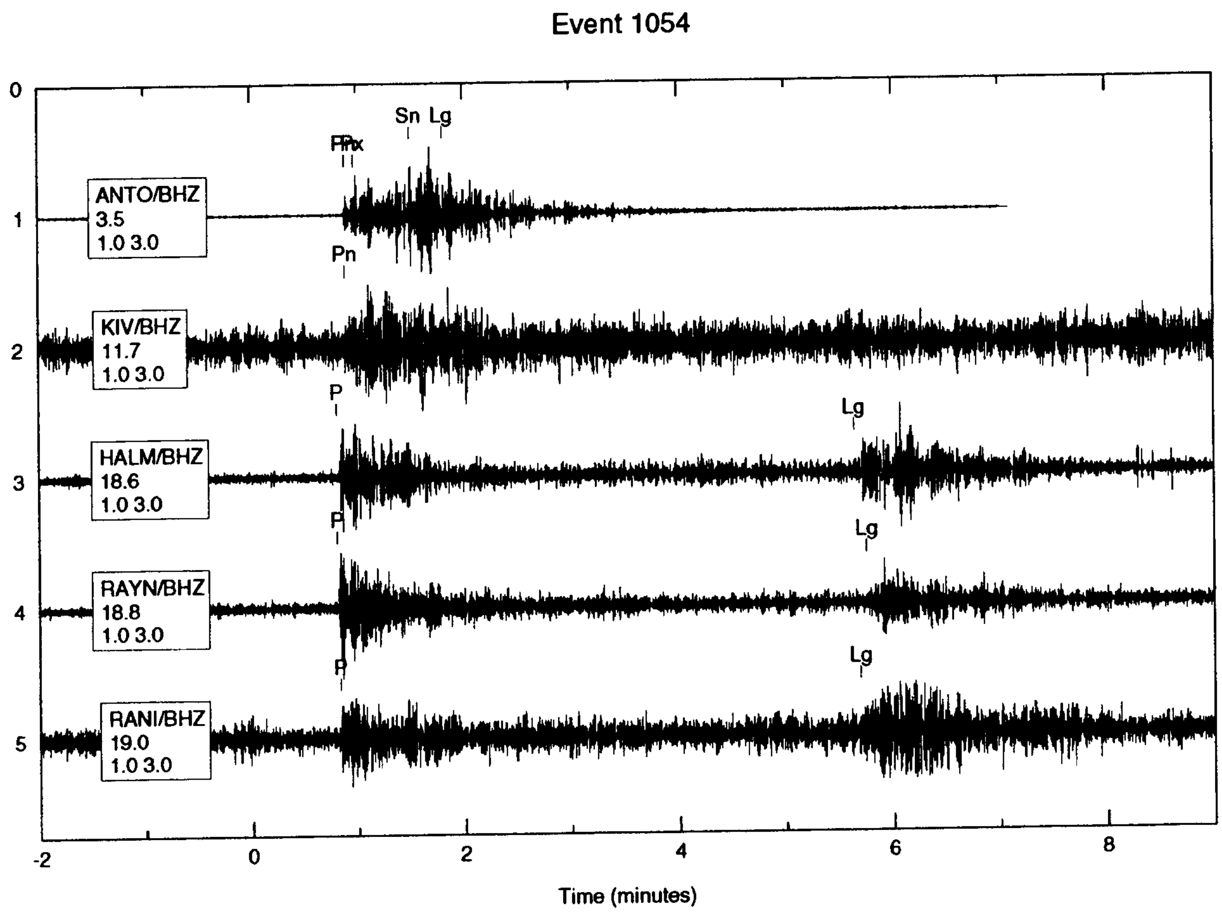
Time scale: one unit = two minutes.

Figure 49: Event 1015. This event was not listed in the USGS bulletin. It is located near the event shown in Figure 47.



Time scale: one unit = two minutes.

Figure 50: Event 1022. This event is located near Cyprus.



Time scale: one unit = one minute.

Figure 51: Event 1054. This event is located near Mugla, Turkey.

Chapter 6

The Saudi Dataset

The focus of this dataset was to take advantage of waveform data from a temporary network of broadband seismometers sited in Saudi Arabia which had recently been made available to the CTBT research community through the IRIS DMC. These data were collected primarily by researchers from UCSD, King Saud University and Boise State University (Vernon *et al.*, 1996).

We compiled event directories for 258 events which were located at regional distances to at least one of the stations in the temporary Saudi network. The events cover the period between November 1995 and May 1996. Data from the temporary Saudi Network have been supplemented with data from other stations from the IRIS archives.

Interactive waveform analysis of the 258 events in this dataset took over one year to complete.[33] The manual review of 6,863 waveforms resulted in a total of 3,652 phases being associated. Several real but as yet unidentifed phases were noted on the waveforms. Further research into the characteristics of the region may result in a better understanding of the observations made during review of this dataset.

About the Saudi Experiment

The following information is summarized from the IRIS Web Site.[34]

> The Saudi Arabian Portable Broadband Deployment was sponsored by DOE.
>
> Beginning in late 1995, 7 stations were deployed across Saudi Arabia. Sites were equipped with STS-2 seismometers, 24-bit Reftek 72A-08 digitizers with GPS timekeeping. Data were recorded with a pass band of 0.008 to 50 Hz and sampled at 40 sps. In June of 1996, two more stations were added and station RAYN was upgraded to a permanent GSN station. The temporary sites were demobilized in February 1997.

Continuous data from this experiment are available from the IRIS DMC. Preliminary results were reported at the 18^{th} Annual Seismic Research Symposium by Vernon *et al.* (1996).

[33] All analysis for this dataset was done by Flori Ryall on an intermittent, part-time basis. The work was done on-site at LLNL and was partly funded by a separate LLNL contract (#1143) to Multimax, Inc.

[34] URL: http://www.iris.washington.edu/PASSCAL/africa.htm#saudi

Construction of the Saudi Event Directories

The target event lists were compiled through queries of the "Events" and the "REB" database accounts at CMR. The "Events" account is maintained at CMR with periodic updates of event lists published by the USGS. These include both the weekly and monthly PDEs. The initial queries were constrained as follows:

- Locations within 20 degrees of at least one station in the Saudi Network.
- Event date between 23 November 1995 and 15 May 1996.

The date boundaries on the queries were chosen to match the data available at the time at the DMC.[35] We did not use any lower limit for the magnitudes.

The event lists were then reduced by excluding events which occurred on days when none of the stations in the Saudi Network were operational.[36] The REB and the USGS event lists were then combined to form one list, using the USGS origin when possible. This single, combined list included about 300 events. Events were grouped into 11 geographical clusters as shown in Figure 52.[37] [38]

On a cluster by cluster basis, we started requesting data from IRIS in October 1996. The ReqData program was used to format IRIS Breq_Fast requests and e-mail them to IRIS. After IRIS completed the requests, the data were FTP'd to our machine and converted to CSS3.0 format using IRIS's **rdseed** program (version 4.21)

Data were retrieved for the seven stations in the temporary Saudi network plus additional IRIS stations: AAE, AAK, ABKT, ANTO, ARU, ATD, BGCA, BRVK, DBIC, GRFO, KIEV, KIV, KMBO, KONO, KURK, MSEY, NIL, OBN, WMQ. Not all stations were requested for each cluster. Only stations within regional distances to the events were requested. Requested event segments start 3 minutes before the first expected P and extend to twice the expected P-LR time.

[35] The queries were performed in October 1996.

[36] During the early days of the experiment, there were days when no stations were up.

[37] The regions do not necessarily correspond to tectonic boundaries.

[38] A twelfth cluster of 37 events was identified in the Gulf of Aden but was not completed for this project.

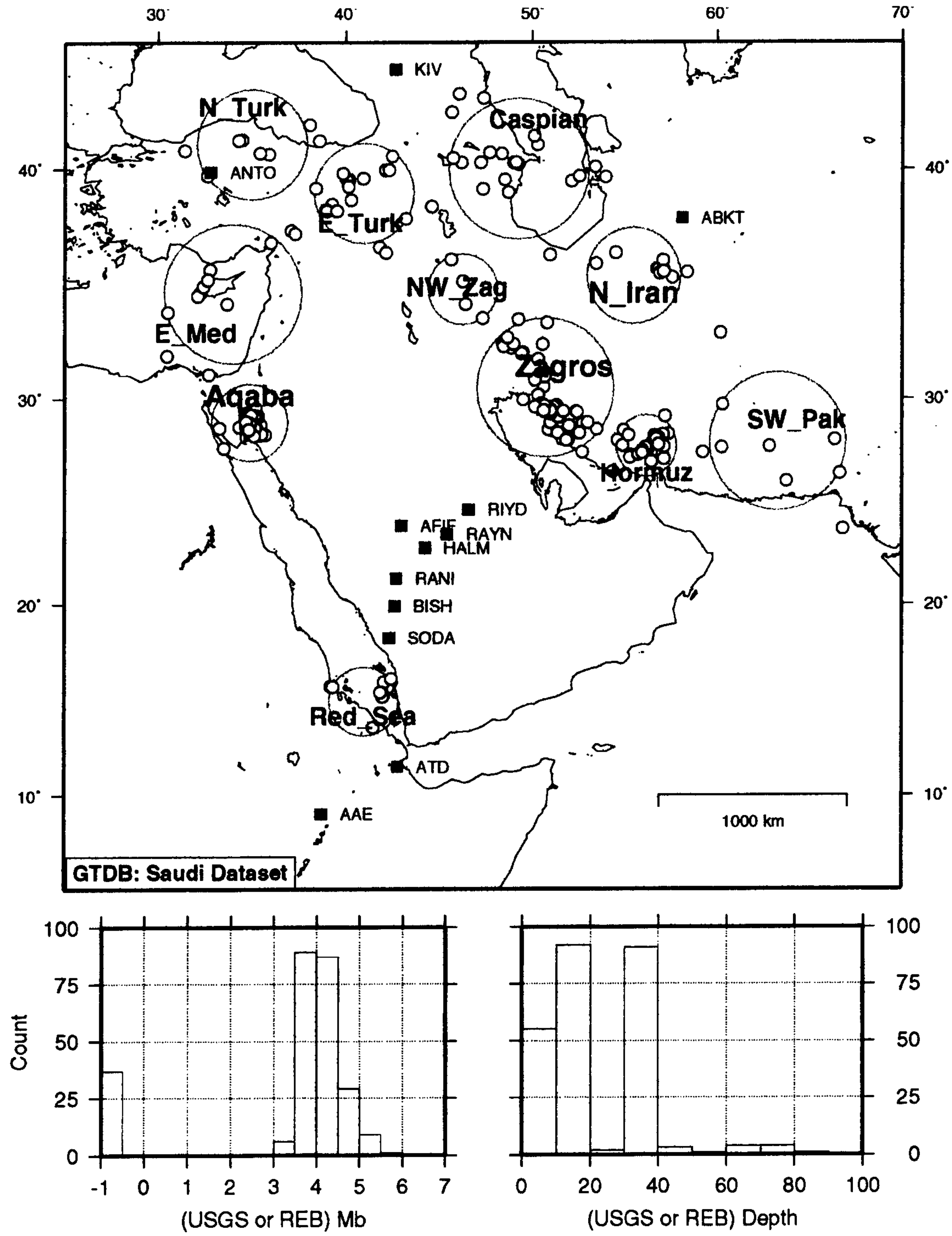


Figure 52: The Saudi Dataset. Events were grouped into geographical regions for analysis. The regions do not necessarily correspond to tectonic boundaries.

Interactive Waveform Analysis

This section summarizes some of the observations made by Flori Ryall during analysis of the Saudi Dataset. The *assoc* table includes 3,652 phases timed and identifed manually using the Geotool program.

The number of waveforms (wf) and the number of associated phases (assoc) are listed for each station in the temporary Saudi network.

sta	lat	lon	wf	assoc
AFIF	23.9	43.0	603	526
BISH	19.9	42.7	51	23
HALM	22.8	44.3	759	610
RANI	21.3	42.8	645	439
RAYN	23.5	45.5	618	583
RIYD	24.7	46.6	249	0
SODA	18.3	42.4	452	285
TAIF	21.3	40.4	0	0
UQSK	25.8	42.4	0	0

We did not review any data from stations TAIF and UQSK because we only requested data through May 1996, and they were installed in June of 1996. Due to instrument problems during the period of our events, BISH had few arrivals and RIYD data were unusable.

The comments below focus mainly on the results observed with respect to the Saudi Network data. However, data from other stations were reviewed simultaneously with the Saudi data and in the same manner. Over 100 arrivals were picked on each of the following stations: BGCA (102); GRFO (102); AAK (138); AAE (153); ARU (198); OBN (229); NIL (258); KIEV (324); ABKT (369); ANTO (377); KIV (549). Data from other stations in the IRIS database are included in this dataset.

The results of analysis are summarized in the bar plots in Figures 53 and 54. The total number of events in each cluster and the total number of associated phases for each cluster are listed at left. Bars show the distribution of associated arrivals by phase type. This display summarizes where the different phase types were observed by the analyst. For example, Lg was observed more often than Pn in the Aqaba cluster, Pg was not observed in the Hormuz cluster, and P was observed more often than Pn for events in the SW Pakistan cluster. The M2 phase, described below, was observed in the Zagros, NW Zagros, E. Turkey, and Caspian Sea clusters.

The Aqaba Region

The Aqaba cluster comprises 66 events believed to be related to the Gulf of Aqaba event of 22 November 1995 (USGS Ms 7.2). The main shock is not recorded on the Saudi network because it occurred the day before the network became operational. However, we did include this event because data were available from the IRIS and GEOSCOPE databases. Hundreds

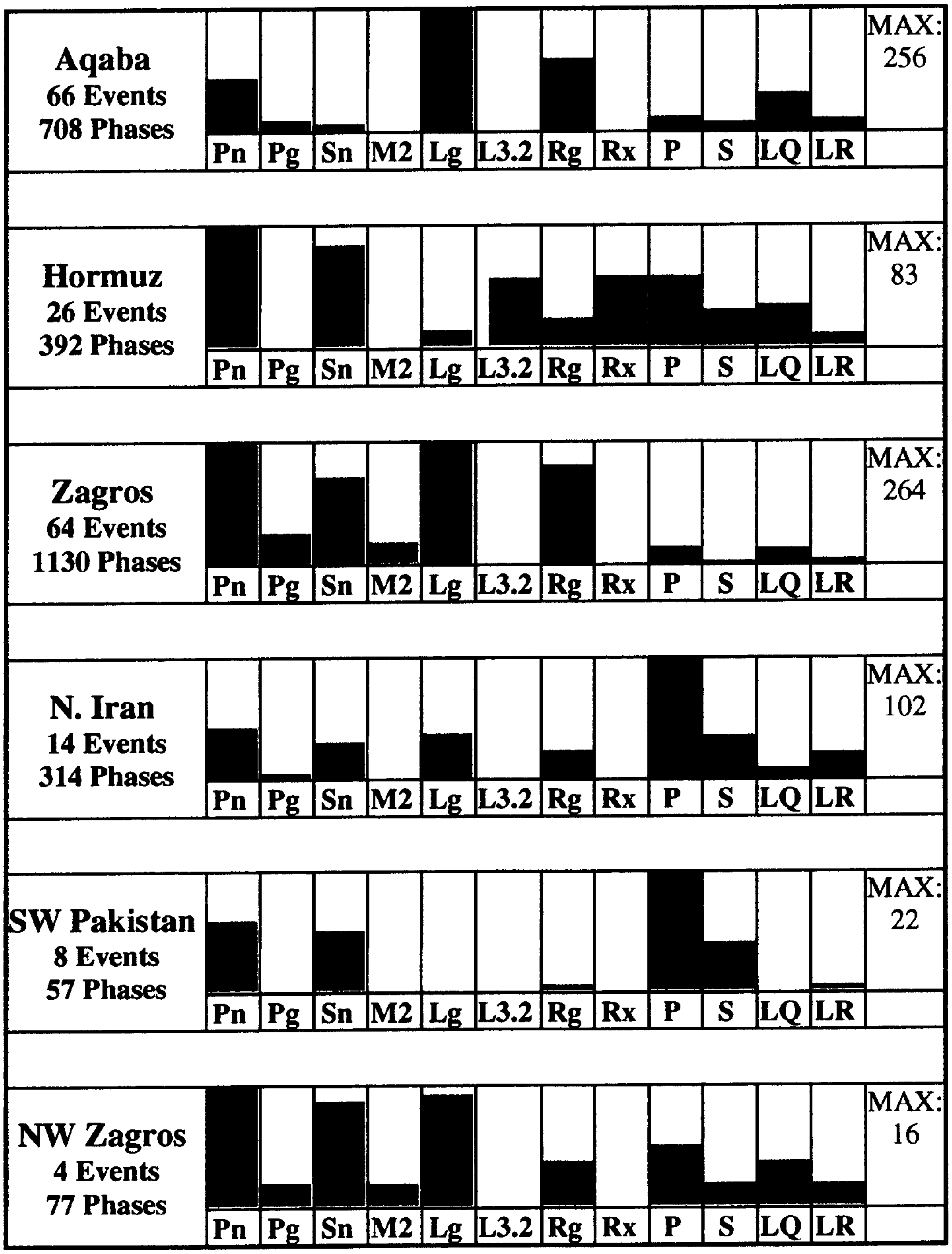


Figure 53: Summary of results by cluster and phase type. The total number of events in each cluster and the total number of associated phases for each cluster are listed at left. Bars show the distribution of associated arrivals by phase type. Within each cluster, bar heights are scaled to the maximum number of associated arrivals, which is listed on the right side of the figure. Six clusters are summarized in this figure and five in the next figure.

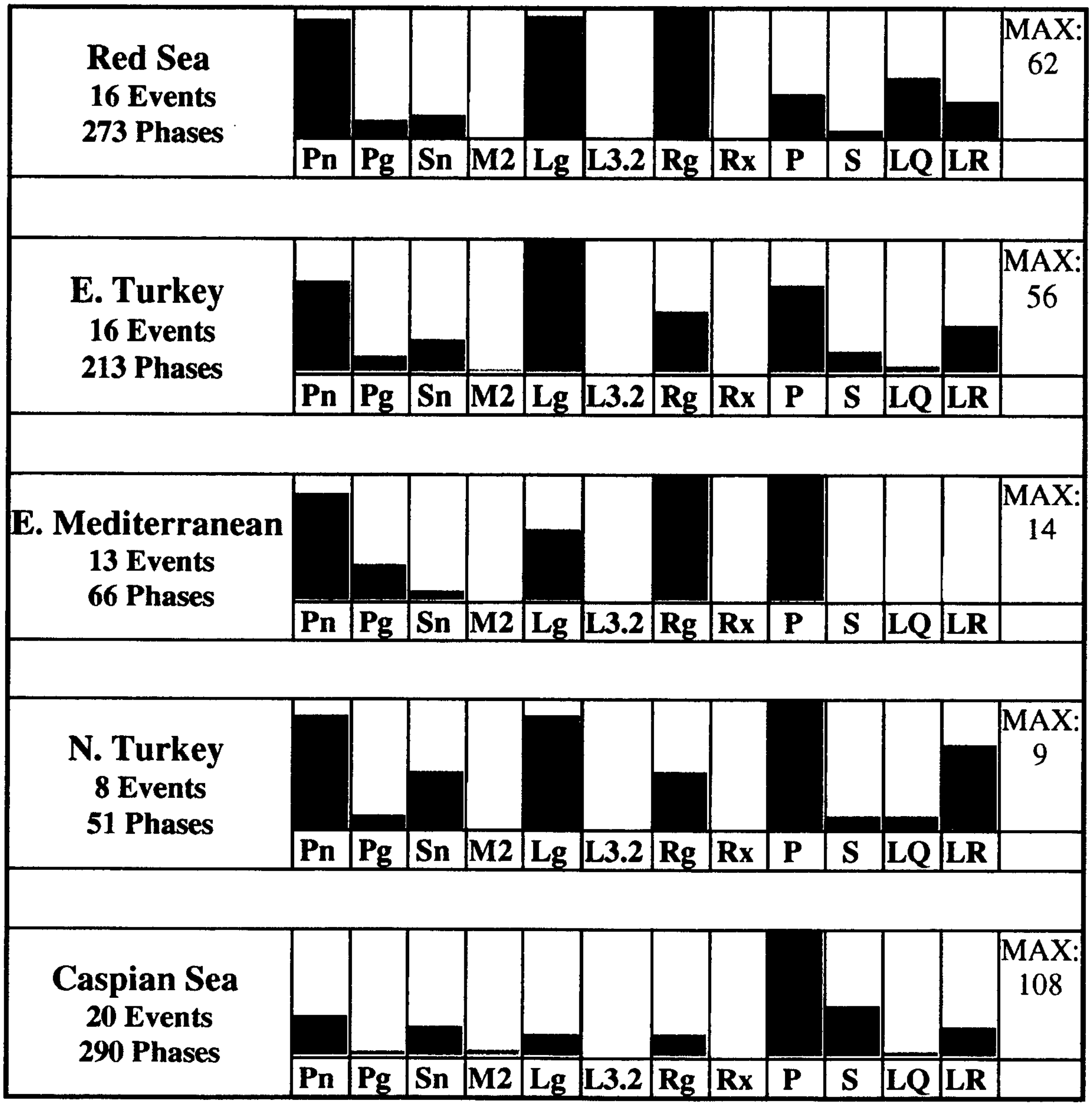


Figure 54: Summary of results by cluster and phase type. See previous figure caption for explanation.

of aftershocks from this event were reported in the JSOP-II bulletin. Distance ranges from the Aqaba events to the Saudi Network stations are between 8 and 13 degrees.

Of the phases recorded by the Saudi network, Lg was the most prominent and consistently recorded. Pn signals were poorly recorded and not readable for many of the events. Similarly, Sn arrivals were not readable for most of the events, with indeterminate phase onsets that were very emergent from the P coda. The plot in Figure 55, on page 118, illustrates these observations.

The Hormuz Region

The Hormuz cluster comprises 26 events located near the Strait of Hormuz. Distance ranges from the Aqaba events to the Saudi Network stations are between 10 and 17 degrees.

One notable feature of this cluster is the appearance at the Saudi stations of a slow (group velocity 3.2-3.3 km/s) "Lg" phase that was labelled L3.2 following Bath (1959). The standard Lg phase (velocity around 3.6 km/s) was not recorded for these events. An example of this observation is shown in Figure 57, on page 120.

The Saudi stations also recorded a later Rayleigh-type wave with group velocity around 2.7 km/s and periods around 10-14s. This phase recorded best on the vertical and radial components and was labelled Rx. A phase with group velocity of about 3.0-3.1 km/s and periods of about 10-14s that recorded best on the horizontal channels was labelled LQ. Examples of these observations are shown in Figure 58, on page 121.

A phase with group velocity of about 3.0-3.1 km/s and periods of about 10-14s that recorded best on the horizontal channels was labelled LQ.

The Zagros Region

The 64 events in the Zagros region do not form a tight spatial cluster. They are distributed along the Zagros Thrust Belt, extending over a distance of about 750 km. Distance ranges from the Zagros events to the Saudi Network stations are between 10 and 15 degrees.

Of interest in this cluster is the recording of a relatively long-period (12s-15s) phase labelled M2 that arrives at about the same time or soon after Sn and records best on the vertical channels. This regional phase had been observed previously on some events recorded on stations ILPA and MAIO. An example of this observation is shown in Figure 60, on page 123.

No attempt was made with the present cluster to distinguish classic Lg or Rg from the slower arrival, L3.2, mentioned in the Hormuz cluster.

The N. W. Zagros Region

The Saudi network typically recorded Pn, Sn, and Lg from the four events in this region. From the largest event (ev600), Pg, Rg and the M2 phase mentioned above were also recorded. Event 600 is shown in Figure 61, on page 124.

The N. Turkey Region

A short-period phase observed on event 650 at first seemed to be an isolated S wave from a separate event. However, since it recorded identically on events 650 and 654, it appears to be a real but unidentified phase. It is therefore labelled as an unidentified S-wave. Further study of more events in the region would be required to determine whether it is in fact a secondary S phase or whether this signal was actually due to a separate event in both instances when it was detected. This observation is shown in Figure 64, on page 127.

The N. Iran Region

Ten of the 14 events in this region are clustered near 35.3N and 57N. Distance ranges from these events to the Saudi stations are between 15.6 and 22.4 degrees. A sample event from this cluster is shown in Figure 65, on page 128.

One event is east of the main cluster and the remaining three events are west of the main cluster. One of the easternmost events is shown in Figure 66, on page 129.

The E. Mediterranian Region

The 13 E. Mediterranean events are between 13 and 20 degrees from the Saudi stations. Two real but unidentified phases were labelled Px and Sx for this cluster. The sample plot in Figure 67, on page 130, shows a sample event from this region.

The S. W. Pakistan Region

The eight events in this region typically record only Pn and Sn (or P and S beyond 16 degrees) at stations in the Saudi Network. Distances to the Saudi Network stations are between 13 and 24 degrees. Sample plots are shown in Figures 68 and 69.

The Caspian Region

Of the twenty events in this cluster, the two largest (872 and 886) record the M2 phase first observed in the Zagros region. This observation is shown in Figure 70, on page 133.

The Red Sea Region

Of the 14 events in the region, 10 are located in the Red Sea. These are some of the closest events to the Saudi Network, ranging in distance from 4 to 10 degrees. A typical Red Sea event is shown in Figure 71, on page 134.

Four of the events from this group are south of 5 degrees latitude, in and near Kenya. They are not shown in the map on Figure 52. One of the Kenyan events is shown in Figure 72, on page 135.

Of the crustal phases recorded by the Saudi Network from this region, Sn was for the most part not readable, with indeterminate phase onsets that were emergent from background

codas. A short period phase recorded by the Saudi network with group velocity of about 3.8-3.9 km/sec and with signal characteristics similar to Lg was labelled "Lg", although further study of this phase may result in a different interpretation.

The E. Turkey Region

Six of the 19 events in this cluster were either too small to read at any station or had only one or two phases readable. Figure 73, on page 136, shows a typical event from this region.

The largest two events of the series (951, 952) occurred 3m 7s apart and recorded mixed coda signals at all of the available stations. These two events are shown in Figure 74, on page 137.

Event Lists

In the event listings that follow, the origin time, latitude, longitude, depth, and mb are defined by the institution listed in the author field.

The author field shows the source of the origin information for each event. USGS/MON indicates the USGS Monthly Bulletin; USGS/PDE is the USGS Preliminary Determination of Epicenters; REB is the Reviewed Event Bulletin.

The USGS hypocenters are based on queries to the "Events" database account at CMR. The query was performed in October 1996. Since that time, some of the PDE hypocenters may have been updated with the Monthly hypocenters.

The parameter, ndef, represents the number of defining phases used by author to define the event. The parameter, nass, is the number of GTDB phases associated with the event. For events with nass equal to zero, data were reviewed but no signal was strong enough to be timed and identified. Waveforms for these events are nevertheless retained in the database. For some of the events in the Saudi Dataset, nass is a bigger number than ndef. This indicates that more phase picks are associated with the event than what was available at the time the hypocenter was determined by author.

The event type field, etype, is "u" (unknown) for these events, although there are several earthquake clusters in this dataset (*e.g.* Aqaba).

GTDB: Saudi Dataset: Region: Aqaba

origin	time		lat	lon	dep	d	mb	ndef	nass	etype	evid	author
1995326	11/22/1995	4:15:09.848	28.68	34.73	1	f	5.5	63	75	u	300	REB
1995327	11/23/1995	18:07:17.200	29.33	34.75	10	G	5.2	267	28	u	301	USGS/MON
1995327	11/23/1995	22:28:19.800	28.66	34.91	10	G	3.9	11	6	u	302	USGS/MON
1995328	11/24/1995	3:35:45.100	29.20	35.12	10	G	-1.0	12	5	u	303	USGS/MON
1995328	11/24/1995	4:09:51.500	29.31	35.08	10	G	-1.0	17	8	u	304	USGS/MON
1995328	11/24/1995	16:43:45.400	28.94	34.71	10	G	4.9	162	8	u	305	USGS/MON
1995328	11/24/1995	22:26:35.400	29.19	34.88	10	G	-1.0	16	7	u	306	USGS/MON
1995329	11/25/1995	11:41:35.200	29.12	34.84	10	G	4.8	86	13	u	307	USGS/MON
1995329	11/25/1995	22:41:30.100	29.05	34.77	12	F	-1.0	11	4	u	308	USGS/MON
1995329	11/25/1995	23:06:20.800	29.18	35.01	10	G	-1.0	11	4	u	309	USGS/MON
1995330	11/26/1995	2:17:47.900	29.09	35.03	10	G	3.6	12	8	u	310	USGS/MON
1995330	11/26/1995	2:39:40.847	28.37	34.90	0	g	3.9	5	8	u	311	REB
1995331	11/27/1995	3:05:40.181	28.73	34.71	0	g	4.0	14	11	u	312	REB
1995332	11/28/1995	12:00:51.500	29.15	34.93	10	G	-1.0	15	5	u	313	USGS/MON
1995332	11/28/1995	21:10:43.600	29.18	34.87	10	G	-1.0	12	6	u	314	USGS/MON
1995333	11/29/1995	9:46:24.100	29.35	34.83	17	F	-1.0	11	6	u	315	USGS/MON
1995335	12/01/1995	9:17:56.800	28.70	34.52	10	G	4.4	36	13	u	316	USGS/MON
1995335	12/01/1995	20:04:59.700	29.23	34.69	10	G	4.4	61	14	u	317	USGS/MON
1995335	12/01/1995	21:18:30.900	29.12	35.05	10	G	3.9	26	9	u	318	USGS/MON
1995336	12/02/1995	0:47:22.200	29.31	34.66	10	G	4.4	68	12	u	319	USGS/MON
1995336	12/02/1995	6:09:48.700	29.20	35.11	10	G	-1.0	13	3	u	320	USGS/MON
1995336	12/02/1995	7:55:39.500	28.80	35.16	10	G	4.4	19	4	u	321	USGS/MON
1995337	12/03/1995	7:54:56.900	28.75	35.30	10	G	-1.0	12	8	u	322	USGS/MON
1995338	12/04/1995	2:45:27.900	28.71	35.22	10	G	-1.0	21	4	u	323	USGS/MON
1995338	12/04/1995	7:34:15.800	28.84	34.94	10	G	-1.0	14	18	u	324	USGS/MON
1995338	12/04/1995	12:39:50.000	28.99	34.83	10	G	-1.0	10	4	u	325	USGS/MON
1995338	12/04/1995	17:56:42.600	29.19	34.79	10	G	-1.0	9	8	u	326	USGS/MON
1995339	12/05/1995	13:17:54.300	29.23	35.35	10	G	-1.0	15	7	u	327	USGS/MON
1995340	12/06/1995	2:57:24.300	29.13	34.75	10	G	-1.0	13	6	u	328	USGS/MON
1995340	12/06/1995	9:47:27.700	29.11	35.17	10	G	-1.0	13	9	u	329	USGS/MON
1995340	12/06/1995	17:57:54.700	28.86	34.68	10	G	4.0	33	23	u	330	USGS/MON
1995342	12/08/1995	4:12:38.900	28.92	34.65	10	G	4.4	56	18	u	331	USGS/MON
1995344	12/10/1995	0:31:16.700	28.79	35.50	10	G	-1.0	8	9	u	332	USGS/MON
1995344	12/10/1995	15:32:20.500	28.81	34.78	10	G	4.3	20	15	u	333	USGS/MON
1995344	12/10/1995	15:33:39.602	28.65	33.25	0	g	4.1	5	8	u	334	REB
1995345	12/11/1995	1:32:06.500	28.88	34.69	10	G	5.0	203	22	u	335	USGS/MON
1995345	12/11/1995	10:54:37.900	28.32	35.44	10	G	-1.0	13	19	u	336	USGS/MON
1995345	12/11/1995	12:45:27.100	29.19	34.81	10	G	-1.0	9	5	u	337	USGS/MON
1995345	12/11/1995	18:35:11.900	29.00	34.77	20	G	-1.0	14	11	u	338	USGS/MON
1995348	12/14/1995	3:53:56.500	28.85	34.63	10	G	4.2	44	20	u	339	USGS/MON
1995348	12/14/1995	4:51:56.700	29.14	34.78	10	G	-1.0	8	6	u	340	USGS/MON
1995349	12/15/1995	6:00:07.500	28.77	34.75	10	G	-1.0	10	16	u	341	USGS/MON
1995353	12/19/1995	12:32:48.900	28.85	34.57	10	G	4.0	23	19	u	342	USGS/MON
1995357	12/23/1995	6:28:58.300	29.56	35.24	9	F	4.4	46	21	u	343	USGS/MON
1995358	12/24/1995	23:04:54.500	29.19	35.34	10	G	-1.0	16	5	u	344	USGS/MON
1995360	12/26/1995	6:19:41.100	29.14	35.24	10	G	-1.0	35	21	u	345	USGS/MON
1995362	12/28/1995	14:22:20.900	29.22	35.14	10	G	-1.0	13	7	u	346	USGS/MON
1995364	12/30/1995	5:13:29.300	28.34	35.71	10	G	3.9	18	8	u	347	USGS/MON
1996002	1/02/1996	19:14:41.000	28.70	34.33	10	G	3.8	29	12	u	355	USGS/PDE
1996003	1/03/1996	10:05:26.500	28.60	35.25	10	G	4.7	62	26	u	356	USGS/PDE
1996004	1/04/1996	14:24:41.500	28.69	34.76	10	G	3.6	13	14	u	359	USGS/PDE

1996004	1/04/1996	17:22:39.400	28.72	34.74	10	G	3.9	18	18	u	361	USGS/PDE
1996004	1/04/1996	17:34:48.200	28.68	34.68	10	G	3.6	6	10	u	362	USGS/PDE
1996006	1/06/1996	7:36:09.400	28.89	34.93	10	G	3.9	18	9	u	363	USGS/PDE
1996008	1/08/1996	13:18:24.900	29.26	34.71	10	G	4.0	16	12	u	368	USGS/PDE
1996033	2/02/1996	13:15:18.400	28.89	34.94	10	G	3.8	22	11	u	378	USGS/PDE
1996035	2/04/1996	7:23:23.000	29.14	34.65	10	G	3.8	15	9	u	381	USGS/PDE
1996040	2/09/1996	8:15:32.777	27.70	33.51	0	g	3.9	5	0	u	383	REB
1996043	2/12/1996	18:23:46.500	28.36	35.53	10	G	4.1	14	8	u	385	USGS/PDE
1996052	2/21/1996	4:59:51.200	28.80	34.78	10	G	5.1	143	22	u	386	USGS/PDE
1996057	2/26/1996	7:17:25.500	28.65	35.18	10	G	4.9	65	19	u	389	USGS/PDE
1996102	4/11/1996	15:34:28.700	29.25	34.96	10	G	-1.0	5	0	u	391	USGS/PDE
1996104	4/13/1996	16:50:40.300	28.85	34.90	10	G	-1.0	5	3	u	393	USGS/PDE
1996107	4/16/1996	0:12:02.200	28.94	34.67	16	D	3.9	24	19	u	394	USGS/PDE
1995326	11/22/1995	12:47:03.515	28.29	35.13	17	d	4.8	41	9	u	396	REB
1995326	11/22/1995	22:16:55.331	28.56	34.86	16	f	4.5	22	9	u	397	REB

GTDB: Saudi Dataset: Region: Hormuz

origin time			lat	lon	dep	d	mb	ndef	nass	etype	evid	author
1995337	12/03/1995	15:19:40.218	28.07	54.65	0	g	3.9	8	6	u	400	REB
1995338	12/04/1995	19:35:36.100	27.83	54.88	33	N	4.8	26	29	u	401	USGS/MON
1995355	12/21/1995	7:39:00.200	27.75	57.15	33	N	4.1	15	15	u	402	USGS/MON
1995358	12/24/1995	13:54:11.500	27.37	55.35	33	N	4.1	23	21	u	403	USGS/MON
1995362	12/28/1995	18:23:35.000	27.95	56.55	47	_	4.6	59	22	u	404	USGS/MON
1995362	12/28/1995	20:27:48.300	28.00	56.56	86	_	4.1	15	17	u	405	USGS/MON
1996013	1/13/1996	9:57:17.400	28.35	57.37	33	N	4.3	29	21	u	406	USGS/PDE
1996039	2/08/1996	22:58:51.848	27.48	56.46	69	f	3.6	9	9	u	407	REB
1996051	2/20/1996	0:34:59.500	28.54	54.98	0	g	4.2	4	5	u	408	REB
1996057	2/26/1996	8:08:19.100	28.32	57.09	33	N	5.3	194	19	u	409	USGS/PDE
1996057	2/26/1996	8:09:24.800	28.32	57.10	33	N	5.4	87	3	u	410	USGS/PDE
1996064	3/04/1996	1:35:30.300	27.66	56.25	33	N	4.5	61	25	u	411	USGS/PDE
1996067	3/07/1996	3:28:14.100	28.31	55.22	33	N	3.8	12	10	u	412	USGS/PDE
1996076	3/16/1996	2:31:43.500	28.29	56.63	33	N	4.0	13	19	u	413	USGS/PDE
1996090	3/30/1996	3:31:53.600	27.25	55.30	33	N	3.8	8	6	u	414	USGS/PDE
1996100	4/09/1996	17:38:23.600	28.17	56.86	33	N	4.0	23	16	u	415	USGS/PDE
1996101	4/10/1996	21:50:43.000	28.13	56.74	33	N	4.7	93	25	u	416	USGS/PDE
1996106	4/15/1996	14:10:42.500	26.59	54.38	33	N	4.0	13	13	u	417	USGS/PDE
1996107	4/16/1996	8:23:26.926	27.72	56.14	149	f	3.6	12	7	u	418	REB
1996109	4/18/1996	1:06:31.875	27.16	57.15	0	g	3.5	5	3	u	419	REB
1996109	4/18/1996	20:13:04.500	27.86	56.87	33	N	4.0	24	17	u	420	USGS/PDE
1996117	4/26/1996	15:02:59.300	27.57	55.94	33	N	3.9	16	20	u	421	USGS/PDE
1996124	5/03/1996	0:58:29.619	27.39	55.77	0	g	3.9	12	22	u	422	REB
1996124	5/03/1996	7:36:42.500	29.21	57.21	33	N	4.2	20	11	u	423	USGS/PDE
1996125	5/04/1996	12:33:45.110	27.47	55.96	0	g	3.8	9	10	u	424	REB
1996126	5/05/1996	23:45:13.867	27.06	56.46	0	g	3.9	12	21	u	425	REB

GTDB: Saudi Dataset: Region: Zagros

origin time	lat	lon	dep	d	mb	ndef	nass	etype	evid	author
1995328 11/24/1995 22:44:42.400	32.32	48.94	73	_	4.5	58	15	u	500	USGS/MON
1995329 11/25/1995 8:39:53.428	32.52	48.42	0	g	3.9	4	1	u	501	REB
1995331 11/27/1995 14:32:29.000	32.31	48.92	61	F	5.0	170	16	u	502	USGS/MON
1995331 11/27/1995 17:05:08.119	33.57	49.30	0	g	4.1	6	5	u	503	REB
1995336 12/02/1995 19:31:28.200	32.47	50.57	50	G	4.0	6	5	u	504	USGS/MON
1995352 12/18/1995 3:45:11.000	30.56	50.64	33	N	4.6	70	26	u	505	USGS/MON
1995354 12/20/1995 2:09:21.400	28.61	51.77	33	N	4.5	26	22	u	506	USGS/MON
1995358 12/24/1995 15:06:48.100	32.38	48.48	33	N	4.5	57	23	u	507	USGS/MON
1995365 12/31/1995 10:53:00.900	29.42	52.38	33	N	4.3	22	8	u	508	USGS/MON
1995365 12/31/1995 11:56:39.500	29.39	52.44	33	N	4.7	70	8	u	509	USGS/MON
1996004 1/04/1996 10:31:41.000	32.10	49.52	33	N	4.7	62	32	u	510	USGS/PDE
1996006 1/06/1996 10:31:45.504	29.70	51.32	0	g	4.2	7	20	u	511	REB
1996008 1/08/1996 23:59:30.400	29.56	51.44	33	N	3.9	13	18	u	512	USGS/PDE
1996012 1/12/1996 10:23:26.500	28.40	52.45	121	_	4.0	17	9	u	513	USGS/PDE
1996024 1/24/1996 5:28:06.200	29.49	50.99	33	N	4.4	15	16	u	514	USGS/PDE
1996024 1/24/1996 6:05:28.100	29.64	51.16	35	D	4.5	19	26	u	515	USGS/PDE
1996024 1/24/1996 7:07:05.900	29.46	51.01	64	_	4.6	31	27	u	516	USGS/PDE
1996025 1/25/1996 10:22:24.369	30.18	50.35	0	g	4.1	8	14	u	517	REB
1996025 1/25/1996 18:05:24.600	29.39	50.97	79	_	4.6	10	15	u	518	USGS/PDE
1996026 1/26/1996 11:40:39.589	29.42	50.69	0	g	4.0	11	10	u	519	REB
1996026 1/26/1996 13:11:14.000	29.39	50.98	33	N	4.5	37	28	u	520	USGS/PDE
1996026 1/26/1996 17:02:20.700	29.41	51.04	70	_	4.1	17	20	u	521	USGS/PDE
1996026 1/26/1996 19:01:28.800	28.80	52.44	33	N	4.5	26	19	u	522	USGS/PDE
1996028 1/28/1996 2:58:29.434	28.53	51.13	0	g	3.9	6	6	u	523	REB
1996031 1/31/1996 20:43:27.795	31.80	50.35	0	g	4.4	18	12	u	524	REB
1996044 2/13/1996 20:43:28.707	28.58	50.90	262	f	3.2	6	10	u	525	REB
1996047 2/16/1996 21:40:18.508	31.17	50.77	133	f	3.8	23	19	u	526	REB
1996063 3/03/1996 8:45:36.300	27.51	52.70	33	N	3.8	10	15	u	527	USGS/PDE
1996068 3/08/1996 1:48:56.200	28.06	51.95	33	N	4.1	21	29	u	528	USGS/PDE
1996069 3/09/1996 15:19:09.600	28.59	53.51	33	N	3.8	6	1	u	529	USGS/PDE
1996073 3/13/1996 8:05:30.000	28.87	51.61	33	N	4.0	13	20	u	530	USGS/PDE
1996075 3/15/1996 7:05:52.775	28.91	51.01	0	g	4.2	4	21	u	531	REB
1996076 3/16/1996 3:24:51.800	29.17	51.43	33	N	4.0	10	11	u	532	USGS/PDE
1996076 3/16/1996 20:18:33.000	29.32	51.03	33	N	4.3	40	33	u	533	USGS/PDE
1996076 3/16/1996 20:21:41.500	29.41	50.89	33	N	4.0	13	17	u	534	USGS/PDE
1996077 3/17/1996 9:00:12.430	29.49	50.85	0	g	4.0	5	16	u	535	REB
1996078 3/18/1996 3:11:42.700	29.48	51.01	33	N	4.0	27	21	u	536	USGS/PDE
1996079 3/19/1996 20:40:38.048	29.54	50.89	0	g	4.3	5	23	u	537	REB
1996080 3/20/1996 1:54:53.700	28.40	51.41	41	D	3.9	11	20	u	538	USGS/PDE
1996080 3/20/1996 22:24:04.400	29.47	50.99	33	N	4.5	34	32	u	539	USGS/PDE
1996080 3/20/1996 22:28:54.581	29.48	50.86	0	g	4.2	6	0	u	540	REB
1996083 3/23/1996 4:02:11.300	28.88	52.77	33	N	4.3	46	26	u	541	USGS/PDE
1996087 3/27/1996 3:33:47.700	28.74	52.00	33	N	4.0	17	24	u	542	USGS/PDE
1996089 3/29/1996 3:19:36.778	29.45	50.92	0	g	4.1	8	23	u	543	REB
1996091 3/31/1996 15:07:24.500	29.44	50.84	33	N	3.7	7	12	u	544	USGS/PDE
1996091 3/31/1996 15:12:16.800	29.66	50.62	10	D	4.3	26	31	u	545	USGS/PDE
1996091 3/31/1996 16:02:06.000	32.05	49.47	33	N	4.3	28	28	u	546	USGS/PDE
1996091 3/31/1996 21:13:28.200	29.77	50.52	37	_	4.1	24	27	u	547	USGS/PDE
1996092 4/01/1996 14:20:52.700	29.50	50.83	33	N	4.2	15	18	u	548	USGS/PDE
1996092 4/01/1996 14:21:59.600	29.47	50.98	33	N	4.2	10	5	u	549	USGS/PDE
1996092 4/01/1996 14:34:18.004	31.02	50.68	184	f	3.5	11	11	u	550	REB

1996092	4/01/1996	16:51:40.400	29.68	50.68	33	N	4.2	18	22	u	551	USGS/PDE
1996093	4/02/1996	4:43:08.624	29.62	50.18	0	g	3.9	4	9	u	552	REB
1996093	4/02/1996	10:41:24.400	29.43	51.70	33	N	3.9	15	29	u	553	USGS/PDE
1996097	4/06/1996	13:49:09.708	29.96	49.55	0	g	3.8	3	8	u	554	REB
1996098	4/07/1996	4:23:25.486	29.47	50.64	0	r	3.8	5	11	u	555	REB
1996101	4/10/1996	20:26:07.800	28.87	52.74	33	N	4.2	39	25	u	556	USGS/PDE
1996102	4/11/1996	20:00:12.200	32.49	49.02	33	N	3.8	12	12	u	557	USGS/PDE
1996105	4/14/1996	6:32:25.475	28.91	53.01	0	g	3.8	5	9	u	558	REB
1996111	4/20/1996	18:30:28.200	28.06	51.87	33	N	4.0	38	33	u	559	USGS/PDE
1996117	4/26/1996	21:31:22.177	33.42	50.82	0	g	3.8	9	22	u	560	REB
1996122	5/01/1996	22:42:09.100	28.39	52.57	33	N	3.9	12	12	u	561	USGS/PDE
1996127	5/06/1996	10:18:11.000	32.79	48.70	33	N	3.8	11	16	u	562	USGS/PDE
1996131	5/10/1996	15:23:00.300	30.86	50.17	33	N	4.3	28	28	u	563	USGS/PDE

GTDB: Saudi Dataset: Region: NW Zagros

origin time			lat	lon	dep	d	mb	ndef	nass	etype	evid	author
1996028	1/28/1996	8:43:16.100	34.27	46.45	33	N	4.8	133	43	u	600	USGS/PDE
1996109	4/18/1996	23:46:00.978	33.63	47.35	0	g	3.8	9	11	u	602	REB
1996110	4/19/1996	2:03:39.800	35.24	46.30	33	N	3.6	10	13	u	603	USGS/PDE
1996133	5/12/1996	8:39:29.900	36.18	45.67	33	N	3.5	9	10	u	604	USGS/PDE

GTDB: Saudi Dataset: Region: N. Turkey

origin time			lat	lon	dep	d	mb	ndef	nass	etype	evid	author
1995332	11/28/1995	12:09:03.400	41.19	34.45	10	G	-1.0	5	5	u	650	USGS/MON
1995336	12/02/1995	21:15:13.700	40.61	35.91	10	G	-1.0	5	2	u	651	USGS/MON
1995347	12/13/1995	11:16:22.300	41.17	34.28	10	G	-1.0	5	0	u	652	USGS/MON
1995349	12/15/1995	6:35:57.000	41.13	38.61	10	G	4.0	20	5	u	653	USGS/MON
1996077	3/17/1996	14:12:55.900	40.63	35.41	15	D	4.2	48	36	u	654	USGS/PDE
1996085	3/25/1996	1:39:35.700	39.72	32.62	33	N	3.6	14	3	u	655	USGS/PDE
1996099	4/08/1996	2:39:52.624	41.78	38.10	0	g	3.6	3	0	u	656	REB
1996102	4/11/1996	23:41:22.802	40.74	31.41	0	g	3.5	3	0	u	657	REB

GTDB: Saudi Dataset: Region: N. Iran

origin time			lat	lon	dep	d	mb	ndef	nass	etype	evid	author
1995327	11/23/1995	19:29:34.700	36.01	53.44	33	N	4.2	21	22	u	700	USGS/MON
1995364	12/30/1995	18:56:19.956	36.46	54.51	0	g	4.2	12	29	u	701	REB
1996014	1/14/1996	20:05:23.200	36.38	50.97	33	N	4.0	12	22	u	702	USGS/PDE
1996036	2/05/1996	8:28:13.300	35.62	58.38	33	N	4.7	77	41	u	703	USGS/PDE
1996054	2/23/1996	13:57:14.000	35.79	56.77	33	N	4.2	16	23	u	704	USGS/PDE
1996056	2/25/1996	16:14:10.800	35.65	57.07	33	N	4.8	84	49	u	705	USGS/PDE
1996056	2/25/1996	17:04:09.000	35.77	56.82	33	N	4.0	14	14	u	706	USGS/PDE
1996056	2/25/1996	17:42:04.400	35.65	57.05	33	N	4.8	84	47	u	707	USGS/PDE
1996056	2/25/1996	18:13:38.900	35.70	57.12	33	N	4.0	19	14	u	708	USGS/PDE
1996056	2/25/1996	18:18:41.200	36.13	57.09	33	N	3.9	7	13	u	709	USGS/PDE
1996057	2/26/1996	16:34:51.226	35.41	57.60	0	g	4.2	5	6	u	710	REB
1996064	3/04/1996	18:18:04.800	35.57	56.91	33	N	3.9	18	11	u	711	USGS/PDE
1996076	3/16/1996	22:39:35.500	32.97	60.19	16	D	4.2	21	13	u	712	USGS/PDE
1996080	3/20/1996	23:58:16.159	35.66	57.13	0	g	3.9	8	10	u	713	REB

GTDB: Saudi Dataset: Region: E. Mediterranean

origin time			lat	lon	dep	d	mb	ndef	nass	etype	evid	author
1995328	11/24/1995	3:32:33.100	31.97	30.48	10	G	3.5	20	7	u	750	USGS/MON
1995330	11/26/1995	7:49:23.789	37.40	37.10	0	g	-9.0	3	2	u	751	REB
1995330	11/26/1995	10:49:22.600	37.29	37.33	10	G	-1.0	5	0	u	752	USGS/MON
1996040	2/09/1996	22:48:02.600	34.75	32.25	33	N	4.3	56	18	u	753	USGS/PDE
1996058	2/27/1996	18:42:17.417	35.76	32.76	0	g	3.7	3	0	u	754	REB
1996080	3/20/1996	11:48:41.700	36.91	36.01	10	G	3.9	11	19	u	755	USGS/PDE
1996096	4/05/1996	2:14:44.800	34.74	32.26	33	N	3.7	13	5	u	756	USGS/PDE
1996102	4/11/1996	2:13:23.600	33.89	30.55	33	N	3.5	22	0	u	757	USGS/PDE
1996102	4/11/1996	23:15:05.000	34.62	32.12	33	N	3.7	14	5	u	758	USGS/PDE
1996103	4/12/1996	1:37:55.200	35.03	32.42	33	N	3.7	9	4	u	759	USGS/PDE
1996103	4/12/1996	13:09:59.198	35.30	32.68	0	g	3.8	9	4	u	760	REB
1996108	4/17/1996	5:39:34.100	34.27	33.67	33	N	4.0	10	2	u	761	USGS/PDE
1996112	4/21/1996	2:07:11.443	31.11	32.71	0	g	3.3	3	0	u	762	REB

GTDB: Saudi Dataset: Region: SW Pakistan

origin time			lat	lon	dep	d	mb	ndef	nass	etype	evid	author
1996005	1/05/1996	15:50:32.700	26.12	63.76	33	N	4.0	13	10	u	850	USGS/PDE
1996018	1/18/1996	13:04:46.616	23.78	66.80	0	r	3.8	3	5	u	851	REB
1996022	1/22/1996	0:48:46.629	26.48	66.64	0	g	3.8	7	5	u	852	REB
1996041	2/10/1996	5:58:42.870	29.74	60.31	0	g	3.7	6	3	u	853	REB
1996061	3/01/1996	14:18:49.400	27.77	62.85	33	N	4.2	14	5	u	854	USGS/PDE
1996063	3/03/1996	19:27:05.200	28.10	66.38	33	N	4.4	39	15	u	855	USGS/PDE
1996067	3/07/1996	1:43:01.532	27.48	59.25	0	g	3.9	3	6	u	856	REB
1996129	5/08/1996	3:05:37.400	27.73	60.26	33	N	3.8	20	8	u	857	USGS/PDE

GTDB: Saudi Dataset: Region: Caspian

origin time			lat	lon	dep	d	mb	ndef	nass	etype	evid	author
1995362	12/28/1995	16:38:30.900	40.18	49.27	10	G	4.2	22	15	u	870	USGS/MON
1995363	12/29/1995	1:48:13.900	39.56	48.54	71	_	3.6	15	6	u	871	USGS/MON
1996003	1/03/1996	8:42:26.200	39.03	48.73	62	_	4.9	128	41	u	872	USGS/PDE
1996006	1/06/1996	0:56:55.700	40.98	50.29	33	N	3.9	10	9	u	873	USGS/PDE
1996012	1/12/1996	4:33:35.200	40.27	46.22	33	N	4.0	14	8	u	874	USGS/PDE
1996012	1/12/1996	4:38:32.715	40.26	47.26	0	g	3.5	5	7	u	875	REB
1996017	1/17/1996	6:26:37.000	40.26	49.02	33	N	4.0	16	9	u	876	USGS/PDE
1996020	1/20/1996	23:56:27.900	40.43	45.79	33	N	3.9	20	21	u	877	USGS/PDE
1996036	2/05/1996	4:45:43.294	43.00	46.11	47	d	3.8	8	7	u	878	REB
1996058	2/27/1996	2:00:55.700	39.50	52.14	33	N	4.4	47	19	u	879	USGS/PDE
1996066	3/06/1996	9:29:01.800	40.09	53.39	33	N	4.3	34	18	u	880	USGS/PDE
1996068	3/08/1996	12:06:35.602	42.85	47.40	0	g	3.6	6	2	u	881	REB
1996069	3/09/1996	8:55:44.300	39.70	52.53	33	N	4.4	47	7	u	882	USGS/PDE
1996089	3/29/1996	16:08:09.100	40.65	47.72	33	N	3.9	15	9	u	883	USGS/PDE
1996094	4/03/1996	0:49:16.300	41.34	50.11	33	N	3.7	13	9	u	884	USGS/PDE
1996106	4/15/1996	4:56:07.233	42.28	45.71	0	g	3.6	5	8	u	885	REB
1996113	4/22/1996	14:42:32.300	39.16	47.37	29	D	5.0	93	41	u	886	USGS/PDE
1996122	5/01/1996	3:31:23.300	40.27	49.14	33	N	3.6	13	7	u	887	USGS/PDE
1996124	5/03/1996	2:42:48.200	39.65	53.98	33	N	3.7	14	22	u	888	USGS/PDE
1996130	5/09/1996	10:58:42.500	40.62	48.38	33	N	4.2	39	25	u	890	USGS/PDE

GTDB: Saudi Dataset: Region: Red Sea

origin time			lat	lon	dep	d	mb	ndef	nass	etype	evid	author
1996043	2/12/1996	12:44:36.575	3.65	30.24	0	g	4.5	5	4	u	901	REB
1996051	2/20/1996	8:36:43.300	15.78	39.24	10	G	4.5	30	24	u	902	USGS/PDE
1996083	3/23/1996	16:20:16.027	4.10	32.31	0	g	3.6	4	7	u	903	REB
1996093	4/02/1996	1:17:05.300	3.08	35.95	10	G	4.3	20	15	u	904	USGS/PDE
1996094	4/03/1996	3:37:13.100	3.13	35.94	10	G	4.5	17	23	u	905	USGS/PDE
1996098	4/07/1996	5:57:52.700	15.70	42.33	10	G	4.1	20	19	u	906	USGS/PDE
1996107	4/16/1996	12:32:48.500	15.76	39.37	10	G	3.9	19	18	u	907	USGS/PDE
1996121	4/30/1996	3:41:41.200	15.29	42.05	10	G	4.0	16	19	u	908	USGS/PDE
1996121	4/30/1996	15:20:37.220	16.03	42.10	0	g	3.9	8	19	u	909	REB
1996121	4/30/1996	17:36:09.000	15.30	42.06	10	G	4.1	13	19	u	910	USGS/PDE
1996122	5/01/1996	11:45:20.600	15.45	41.99	10	G	4.3	32	22	u	911	USGS/PDE
1996123	5/02/1996	23:12:17.400	15.35	42.05	10	G	4.3	21	22	u	912	USGS/PDE
1996124	5/03/1996	17:04:07.500	16.17	42.48	10	G	3.9	7	18	u	913	USGS/PDE
1996126	5/05/1996	19:39:35.380	13.62	41.53	0	g	3.7	5	12	u	914	REB
1996126	5/05/1996	20:02:58.042	15.24	42.01	0	g	3.9	16	13	u	915	REB
1996126	5/05/1996	20:42:17.400	15.46	41.92	10	G	4.4	13	19	u	916	USGS/PDE

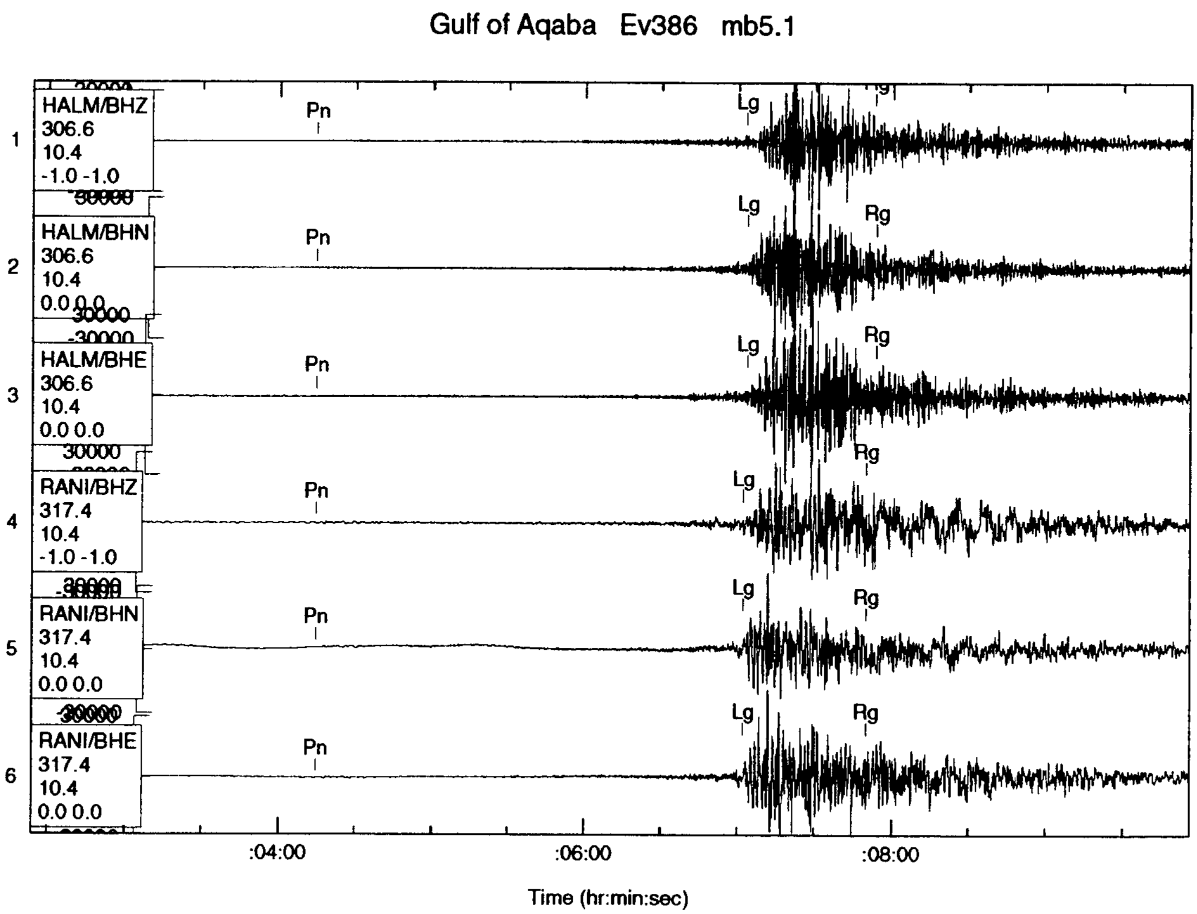
GTDB: Saudi Dataset: Region: E. Turkey

origin time			lat	lon	dep	d	mb	ndef	nass	etype	evid	author
1995332	11/28/1995	11:32:00.700	39.19	38.42	10	G	-1.0	4	2	u	950	USGS/MON
1995339	12/05/1995	18:49:30.400	39.44	40.15	15	G	5.5	375	43	u	951	USGS/MON
1995339	12/05/1995	18:52:37.700	39.55	40.19	10	G	5.3	135	22	u	952	USGS/MON
1995340	12/06/1995	7:49:47.200	39.58	40.03	10	G	-1.0	20	21	u	953	USGS/MON
1995344	12/10/1995	4:57:35.100	39.80	39.87	10	G	-1.0	5	1	u	954	USGS/MON
1995354	12/20/1995	7:31:11.400	39.25	40.17	10	G	-1.0	6	0	u	955	USGS/MON
1996012	1/12/1996	3:22:40.800	39.95	42.15	10	G	4.1	14	11	u	956	USGS/PDE
1996014	1/14/1996	15:17:45.361	36.70	41.82	0	r	3.7	4	1	u	957	REB
1996038	2/07/1996	12:27:09.200	38.51	39.27	33	N	4.1	22	20	u	958	USGS/PDE
1996066	3/06/1996	14:49:05.432	40.52	42.50	0	g	4.0	6	0	u	959	REB
1996073	3/13/1996	12:13:54.697	38.43	44.64	0	g	3.5	4	0	u	960	REB
1996089	3/29/1996	12:22:48.703	36.47	42.17	0	g	3.7	12	16	u	961	REB
1996099	4/08/1996	2:01:56.800	38.30	38.94	10	G	3.1	6	12	u	962	USGS/PDE
1996099	4/08/1996	2:20:43.500	38.23	38.98	10	G	3.8	28	25	u	963	USGS/PDE
1996101	4/10/1996	4:10:31.800	37.91	43.26	10	G	3.6	7	9	u	964	USGS/PDE
1996112	4/21/1996	14:13:57.700	38.70	40.31	10	G	3.6	10	11	u	965	USGS/PDE
1996116	4/25/1996	20:29:38.400	39.95	42.35	33	N	3.4	13	5	u	966	USGS/PDE
1996125	5/04/1996	8:19:42.000	39.59	40.97	33	N	3.8	15	12	u	967	USGS/PDE
1996130	5/09/1996	5:21:41.800	38.22	39.53	33	N	3.7	6	2	u	968	USGS/PDE

Sample Waveform Plots

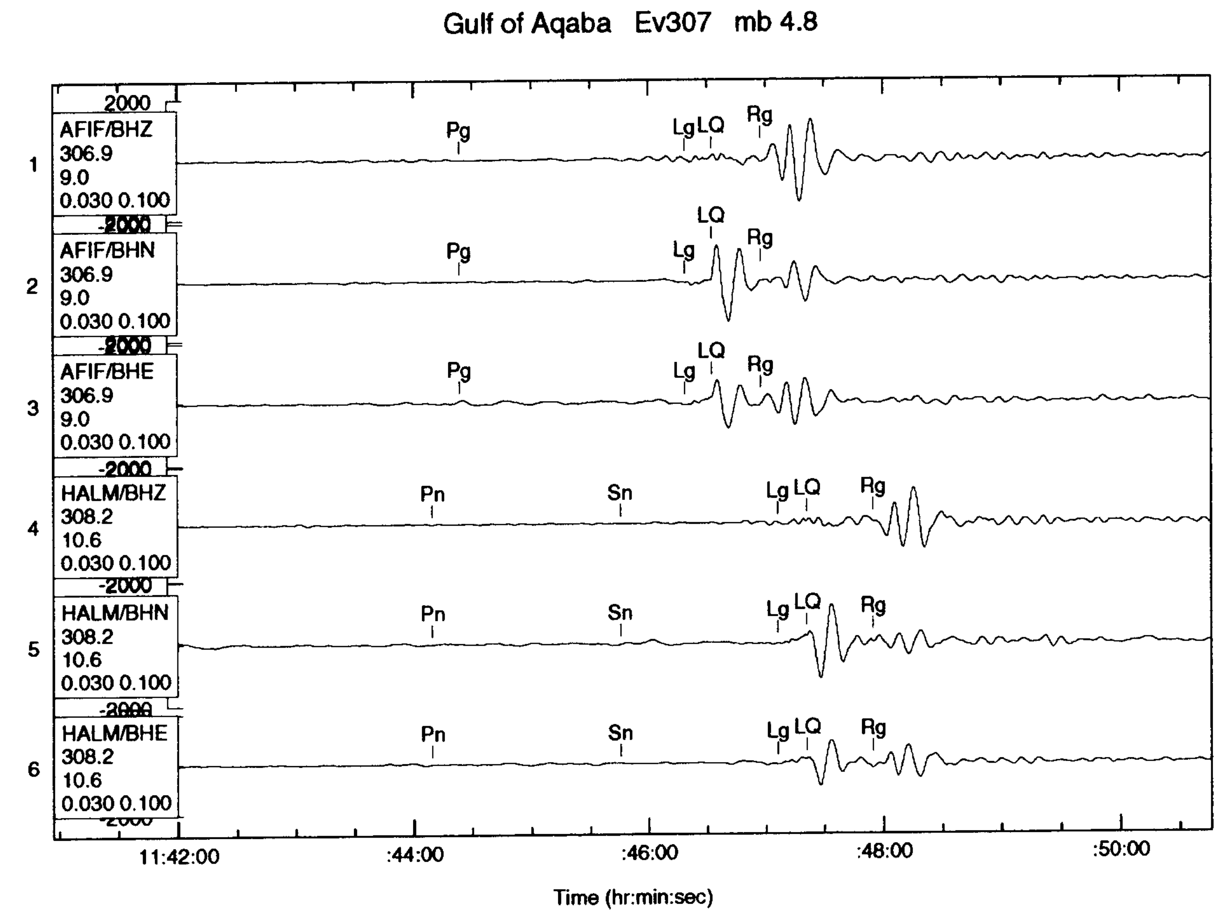
Plots in this section are representative of the data available for events in the Saudi Dataset. One or two plots are shown from each region. Additional sample plots are shown on the GTDB Web Site.

Time scales, which vary from plot to plot, are explained below each plot. Traces are usually aligned on the first arrival. Traces are usually shown with causal bandpass filters applied. Independent vertical scaling was applied to the traces. Information in the waveform tags may include station, channel, station-to-event azimuth, station-to-event distance (degrees) and low and high corner of the bandpass filter applied for display.



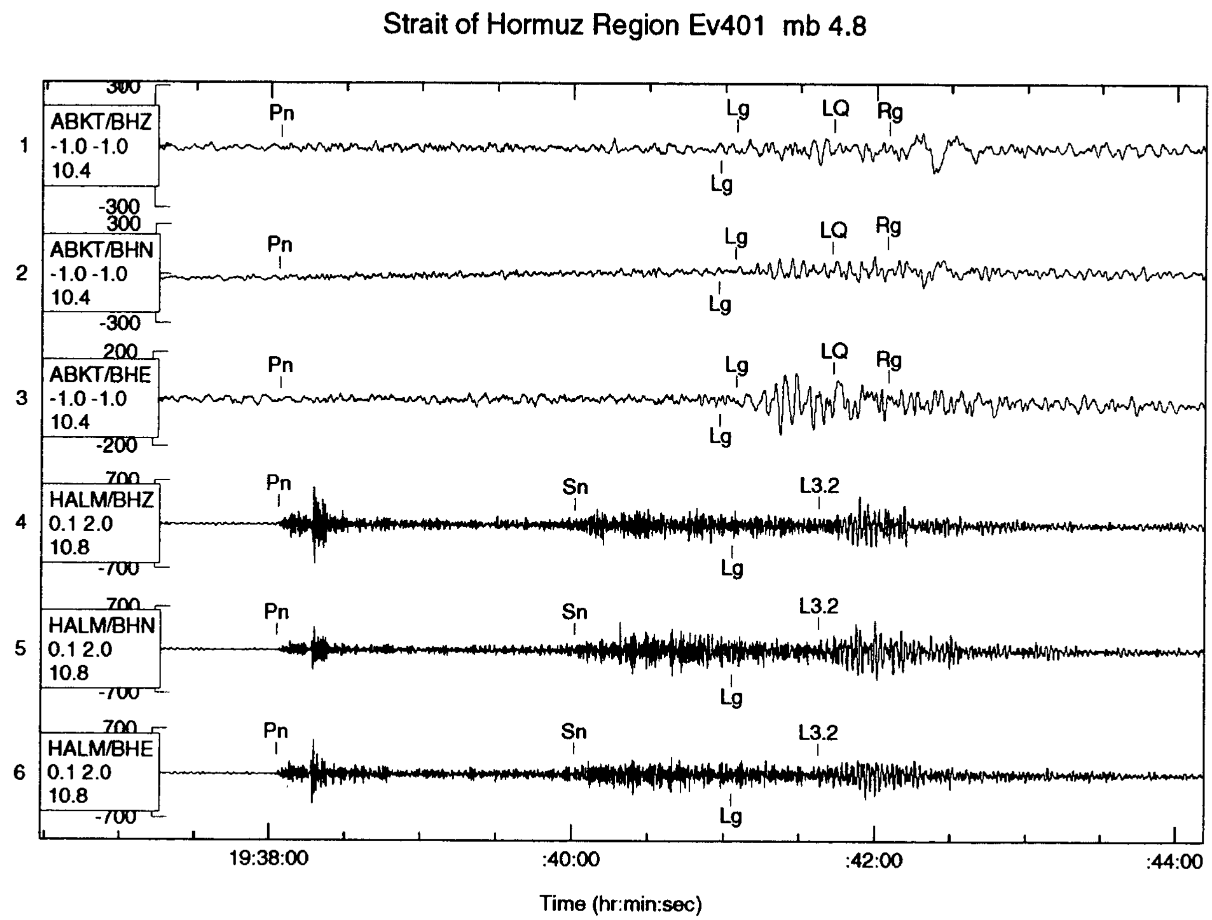
Time scale: two units = one minute.

Figure 55: Event 386 from the Aqaba region. Example of moderate-sized event recording at two 3-component Saudi stations (HALM and RANI), both at a range of 10.4 degrees. All traces are unfiltered. Note large Lg/Pn ratio.



Time scale: two units = one minute.

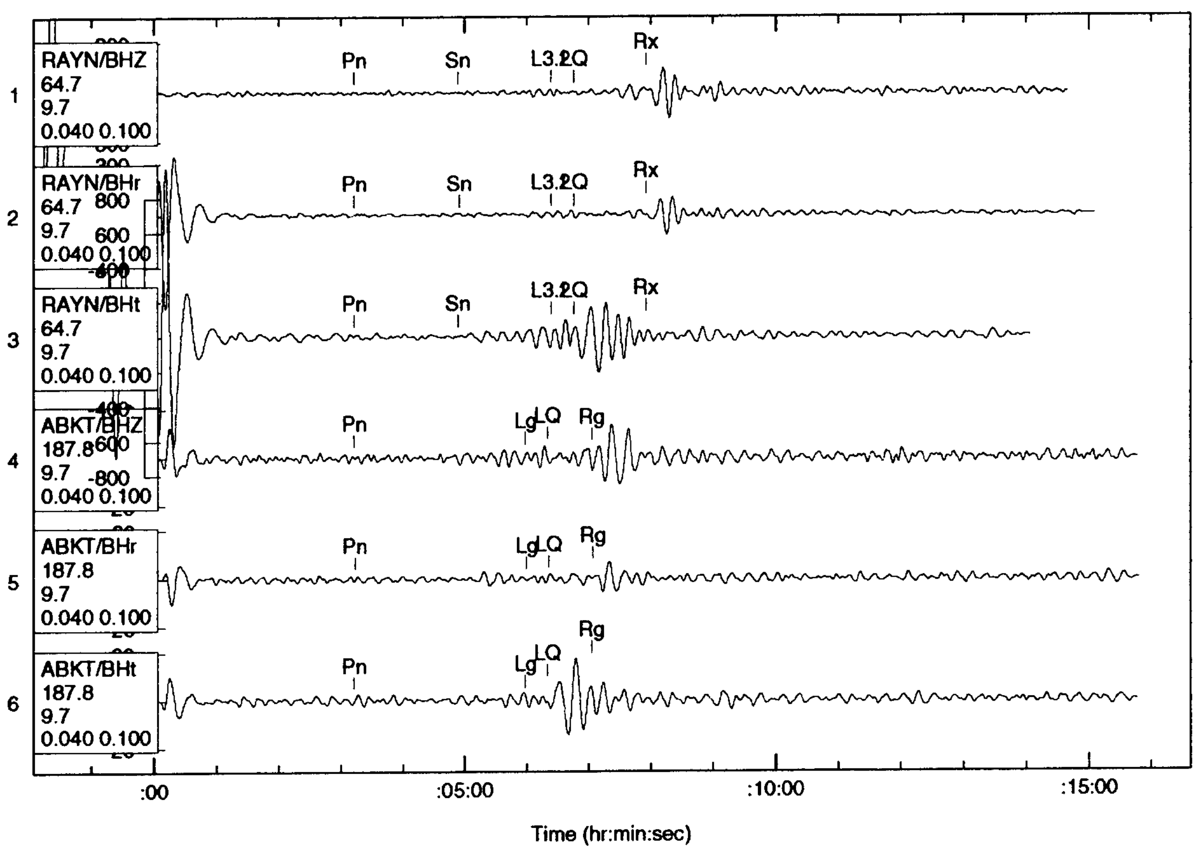
Figure 56: Event 307 from the Aqaba region. Example of surface waves recording at two 3-C Saudi stations (AFIF at 9 degrees, HALM at 10.6 degrees). All traces are filtered at 0.03 - 0.1 Hz.



Time scale: two units = one minute.

Figure 57: Event 401 from the Hormuz region. Station ABKT, at 10.4 degrees, is unfiltered. Saudi station, HALM at 10.8 degrees is filtered at 0.1 - 2.0 Hz. Example of slow Lg labelled L3.2 at Saudi station HALM. Turkmenistan station ABKT, at about same distance, displays more conventional Lg arrival time. Predicted Lg times are plotted beneath waveforms.

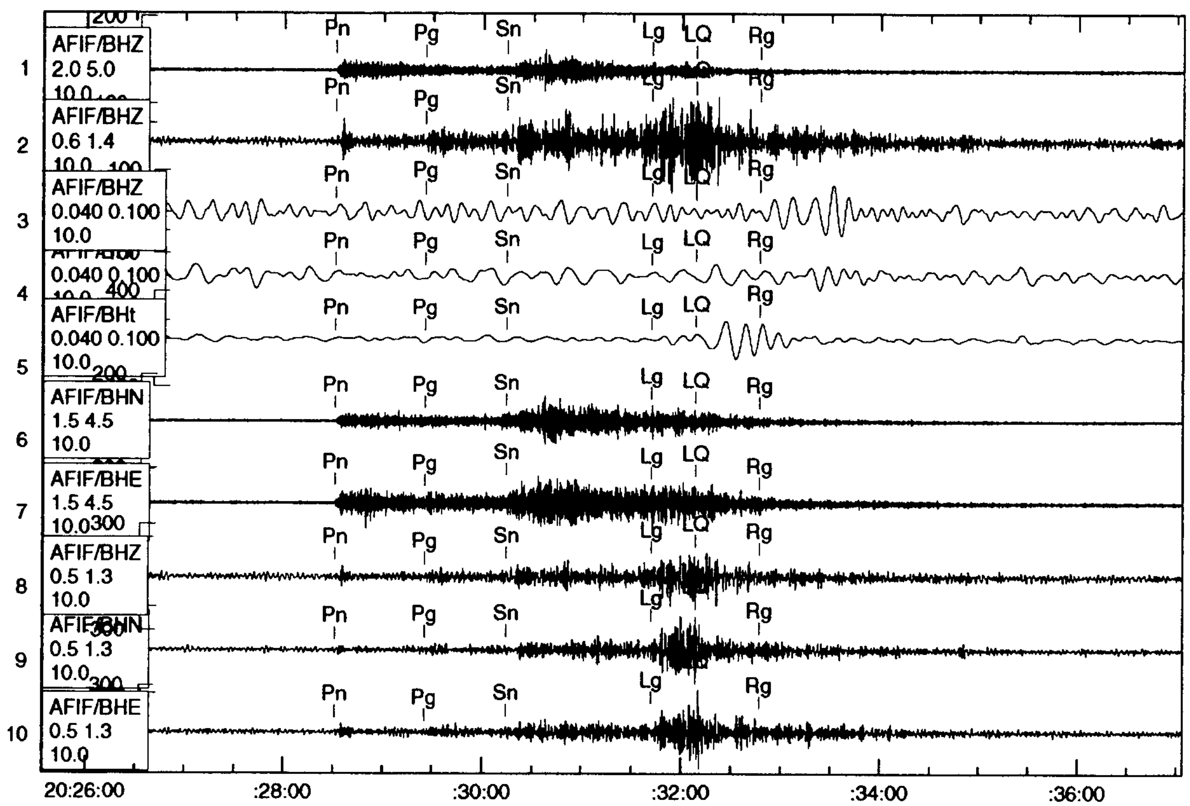
Strait of Hormuz Region Ev403 mb4.1, Ev413 mb4.0



Time scale: one unit = one minute.

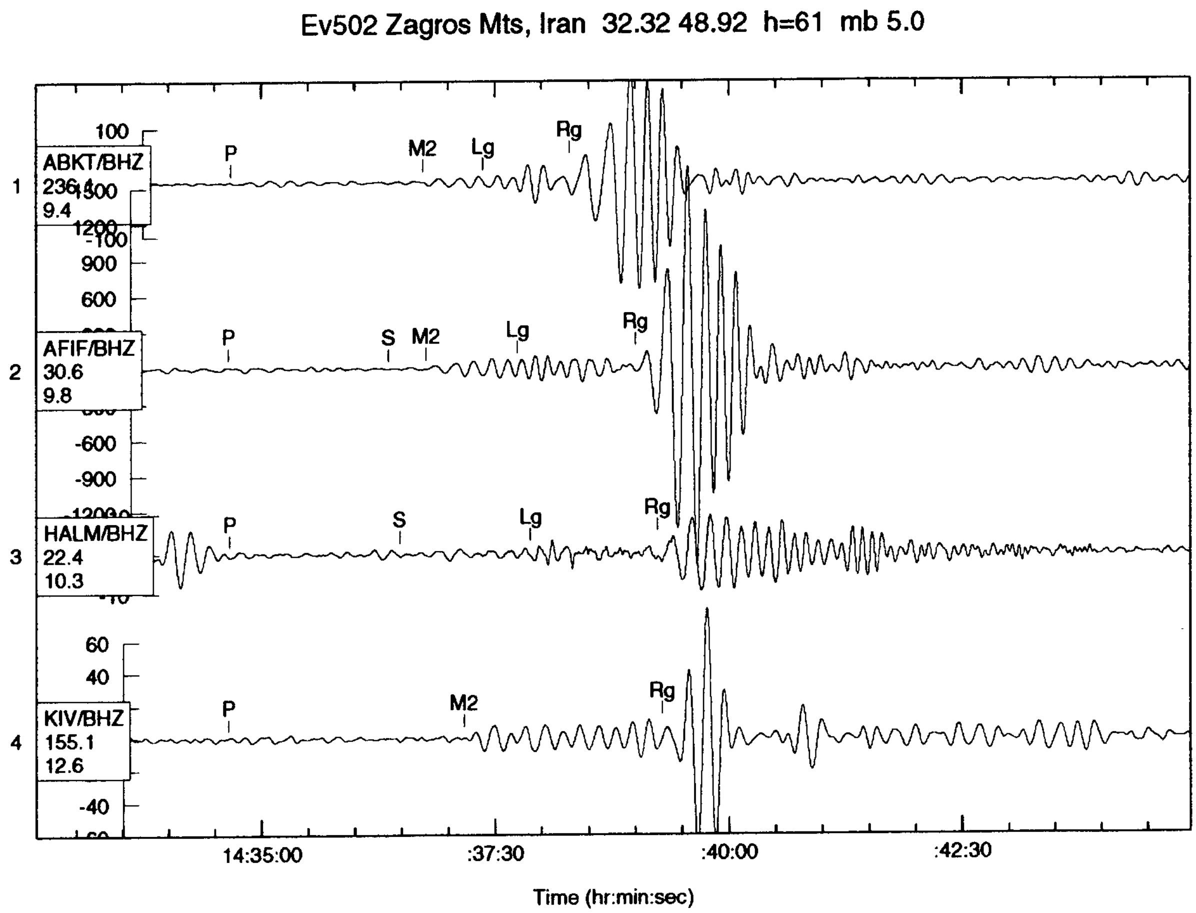
Figure 58: Events 403 and 413 from the Hormuz region. Event ev403 shows slow Rg phase labelled Rx at Saudi station RAYN, distance 9.7 degrees. Event ev413 shows more conventional Rg arrival time at Turkmenistan station ABKT, same distance. All traces filtered at 0.04 - 0.1 Hz. The horizontal channels were rotated to radial and transverse as shown in the waveform tags.

Zagros Mts, Iran Ev556 mb4.2



Time scale: two units = one minute.

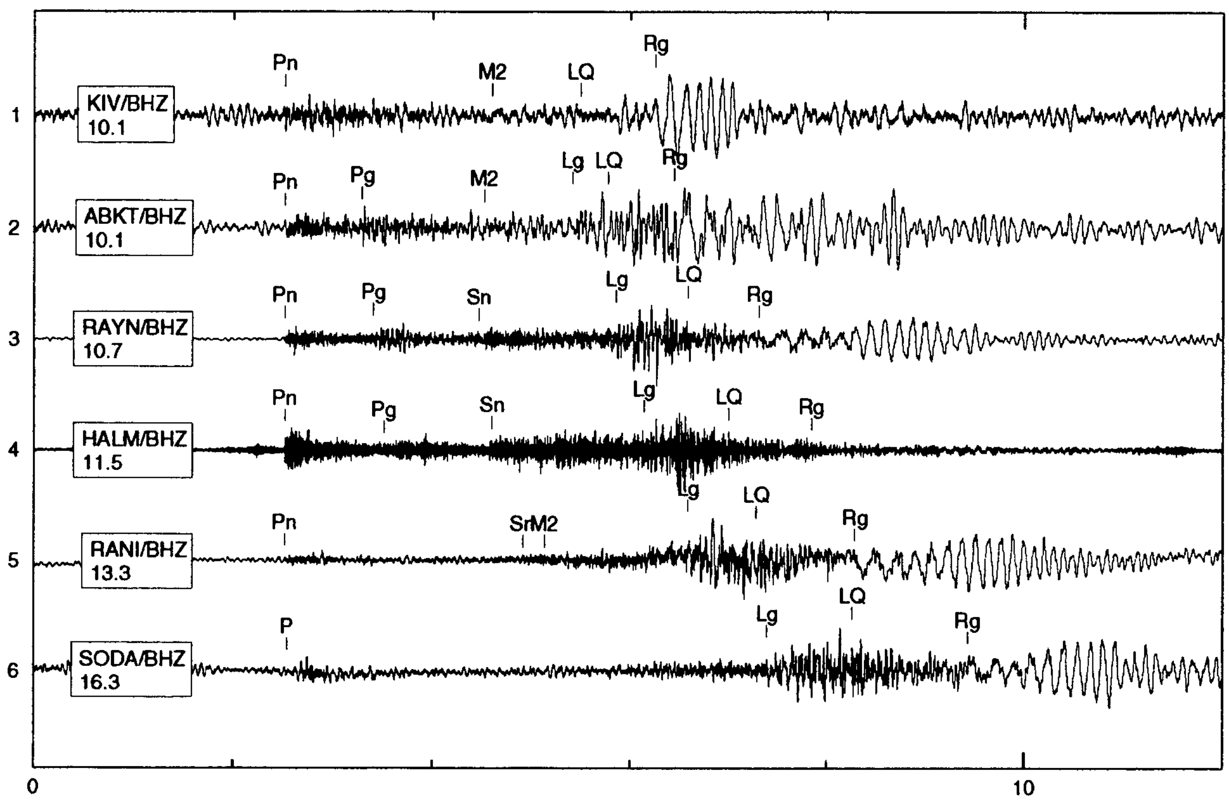
Figure 59: Event 556 from the Zagros region. The event is displayed at Saudi station AFIF with various filters applied to enhance appearance of different phase arrivals. The distance range is 10 degrees. Traces filtered as follows: 1) BHZ (2 - 5 Hz) shows Pn best; 2) BHZ (0.6 - 1.4 Hz) shows Pg best; 3,4,5) BHZ, BHN, BHE (0.04 - 0.1 Hz) shows surface waves best; 6,7) BHN, BHE (1.5 - 4.5 Hz) shows Sn best; 8,9,10) BHZ, BHN, BHE (0.5 - 1.3 Hz) shows Lg best.



Time scale: two units = one minute.

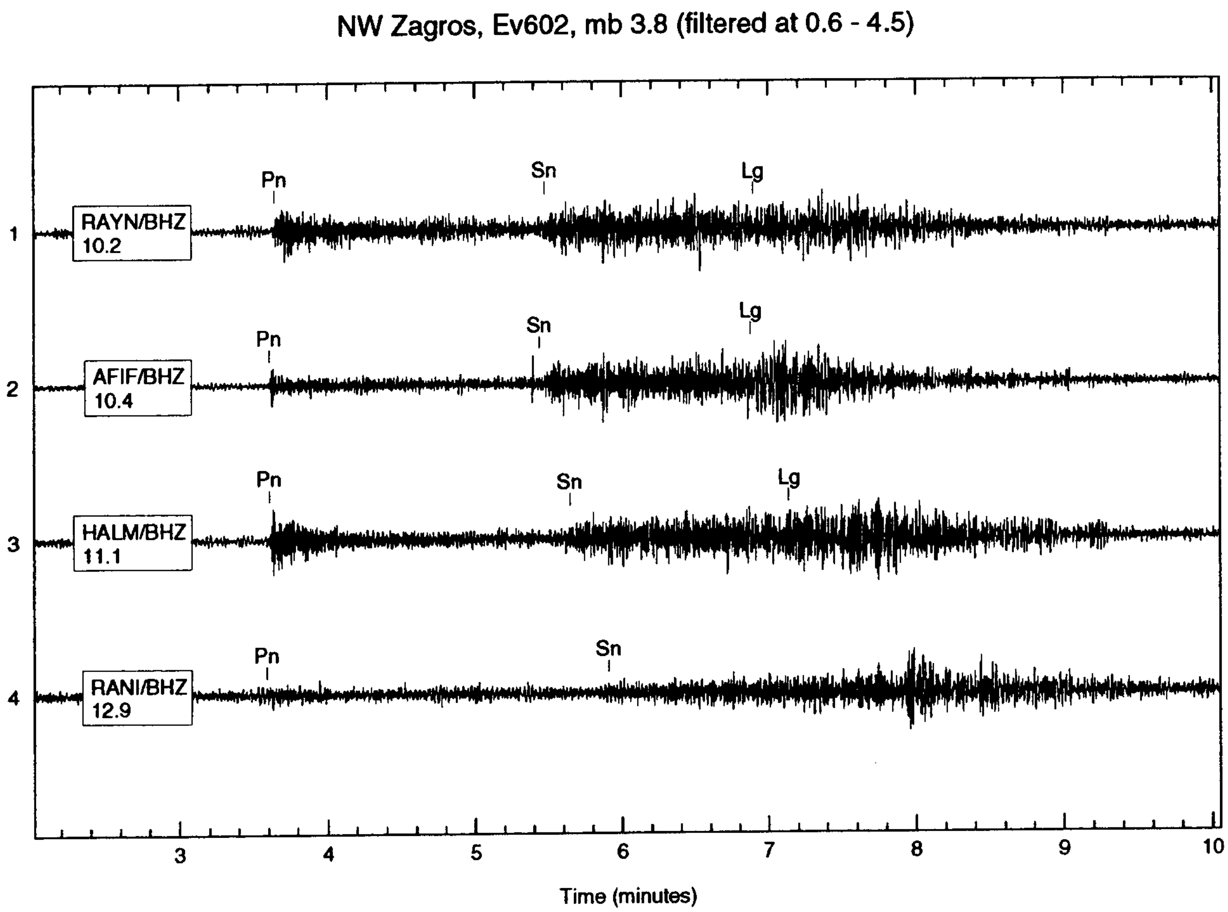
Figure 60: Event 502 from the Zagros region. Four stations are plotted to show the distance ranges between 9.4 and 12.6 degrees. The phase labelled M2 arrives at about the same time or soon after Sn and records best on the vertical channels with periods of about 12-15 seconds. Traces filtered 0.05 - 0.1 Hz.

NW Zagros, Ev600, mb 4.8 (unfiltered)



Time scale: one unit = two minute.

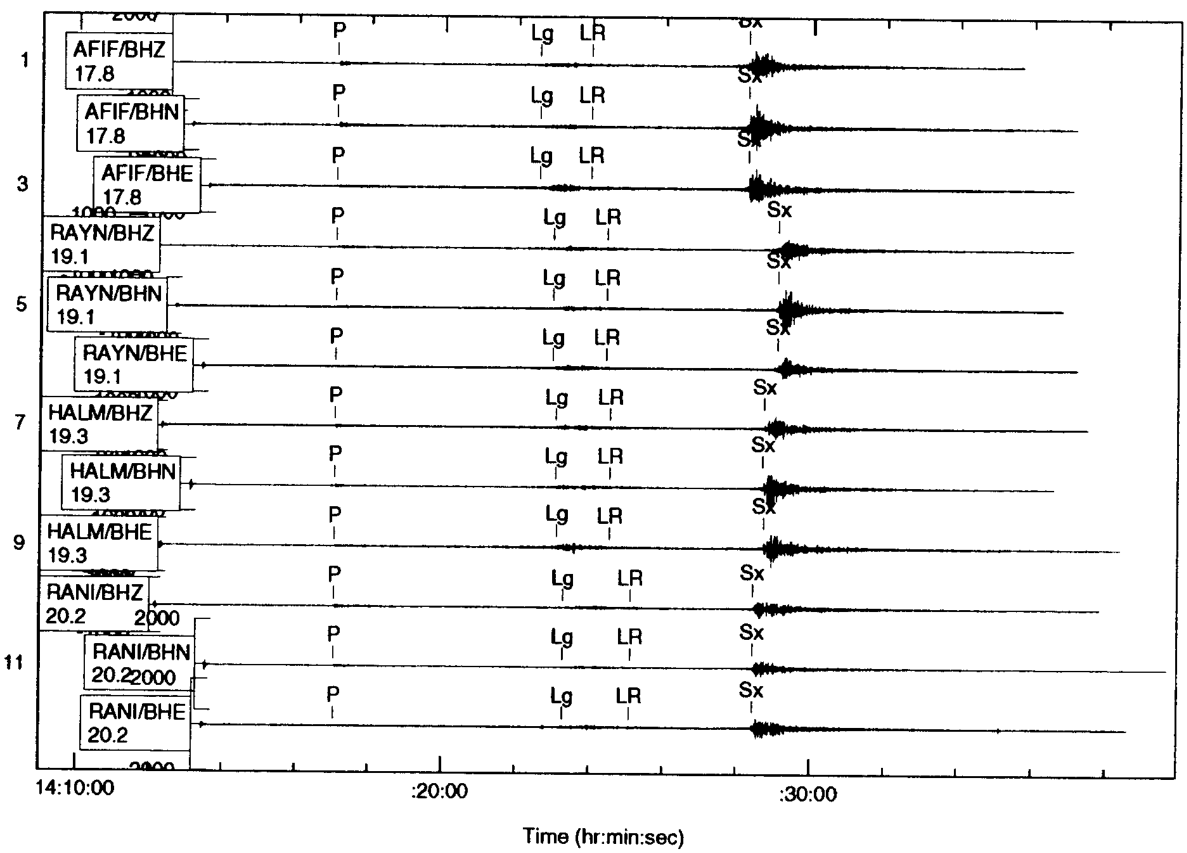
Figure 61: Event 600 from the NW Zagros region. Vertical traces are shown from six sites, including four from the Saudi Network. All traces are unfiltered. Surface waves were consistently observed for this moderate-sized event.



Time scale: five units = one minute.

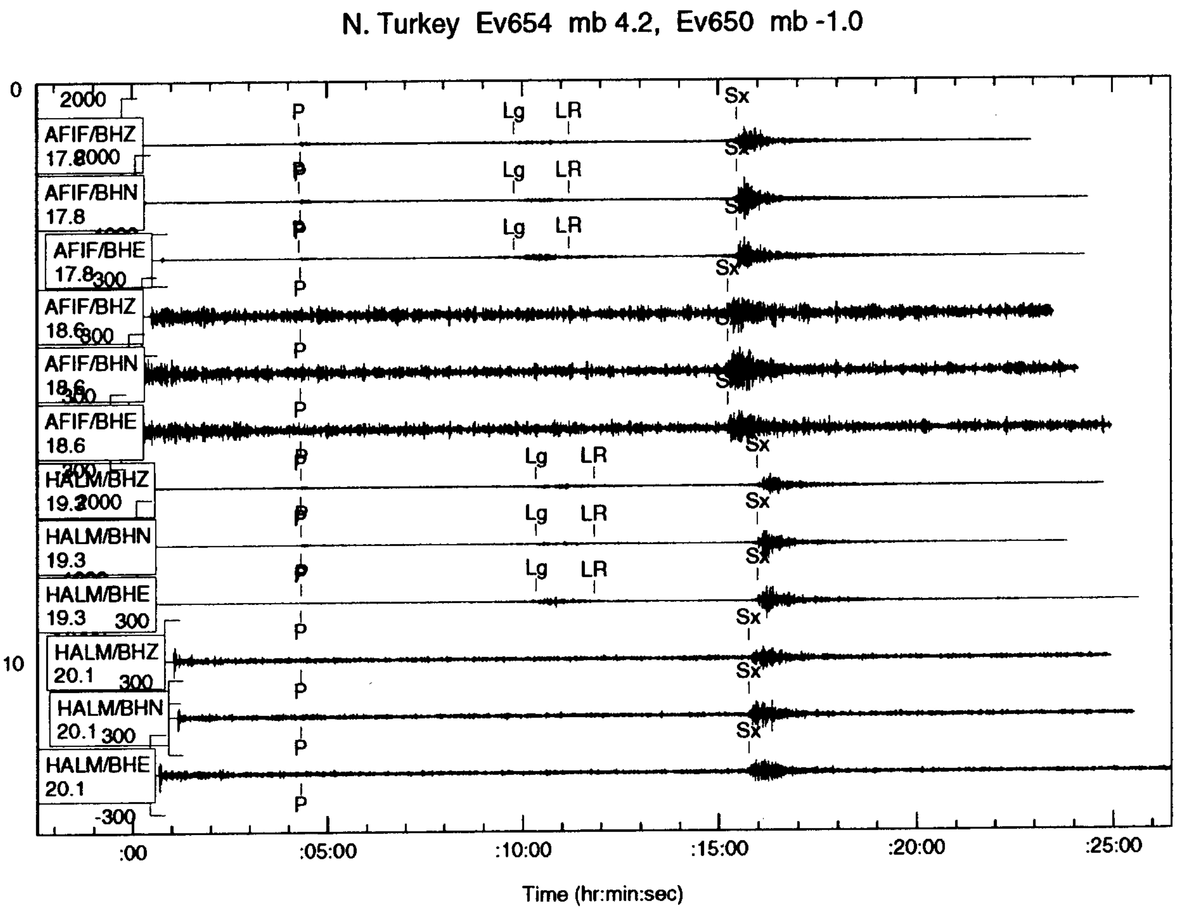
Figure 62: Event 602 from the NW Zagros region. Vertical components of four stations from the Saudi Network are shown. Distance ranges are between 10.2 and 12.9 degrees. All traces are bandpass filtered at 0.6 - 4.5 Hz.

N. Turkey Ev654 mb 4.2



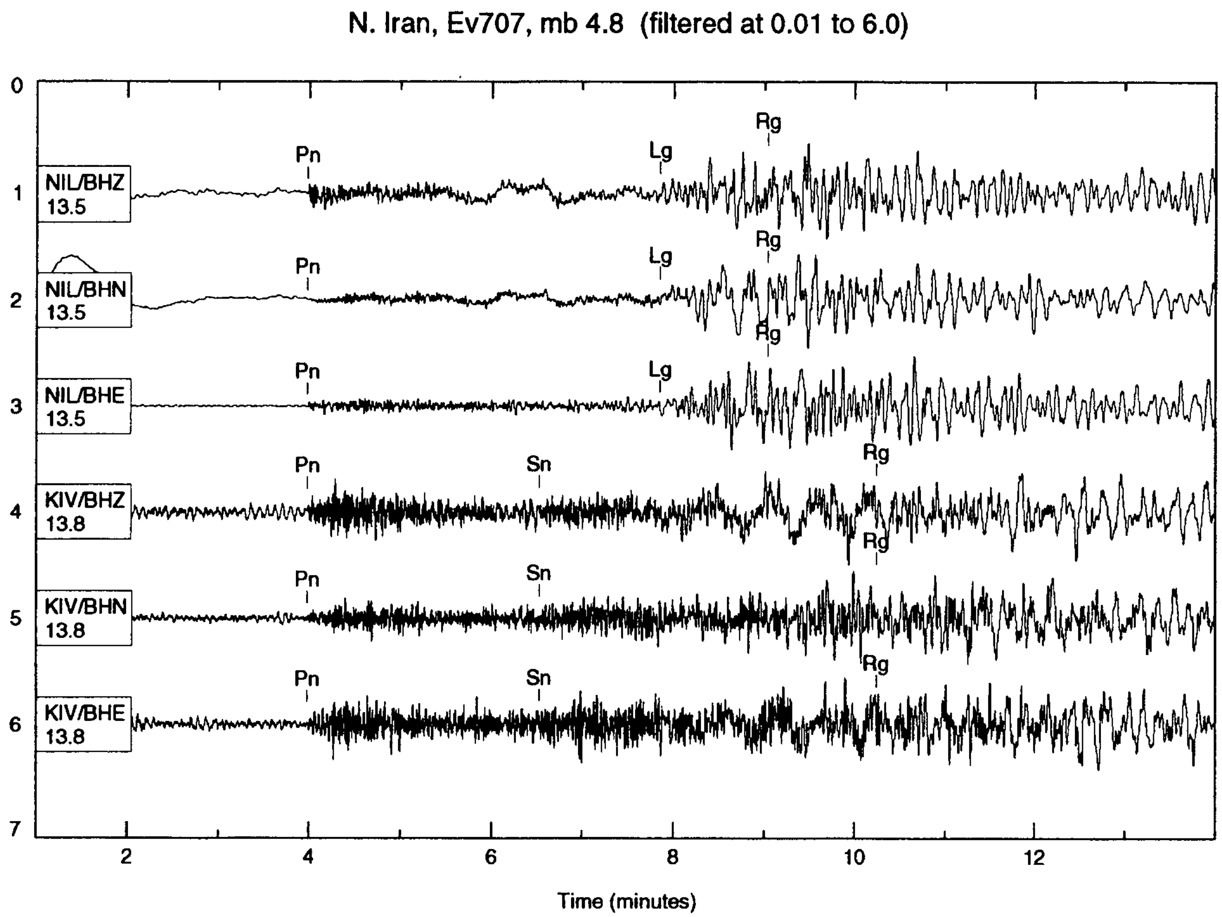
Time scale: one unit = one minute.

Figure 63: Event 654 from the N. Turkey region. Three components are shown at four Saudi stations. Distance ranges are between 17.8 and 20.2 degrees. All traces are filtered at 0.5 - 2.0 Hz. Note the short period phase labelled Sx.



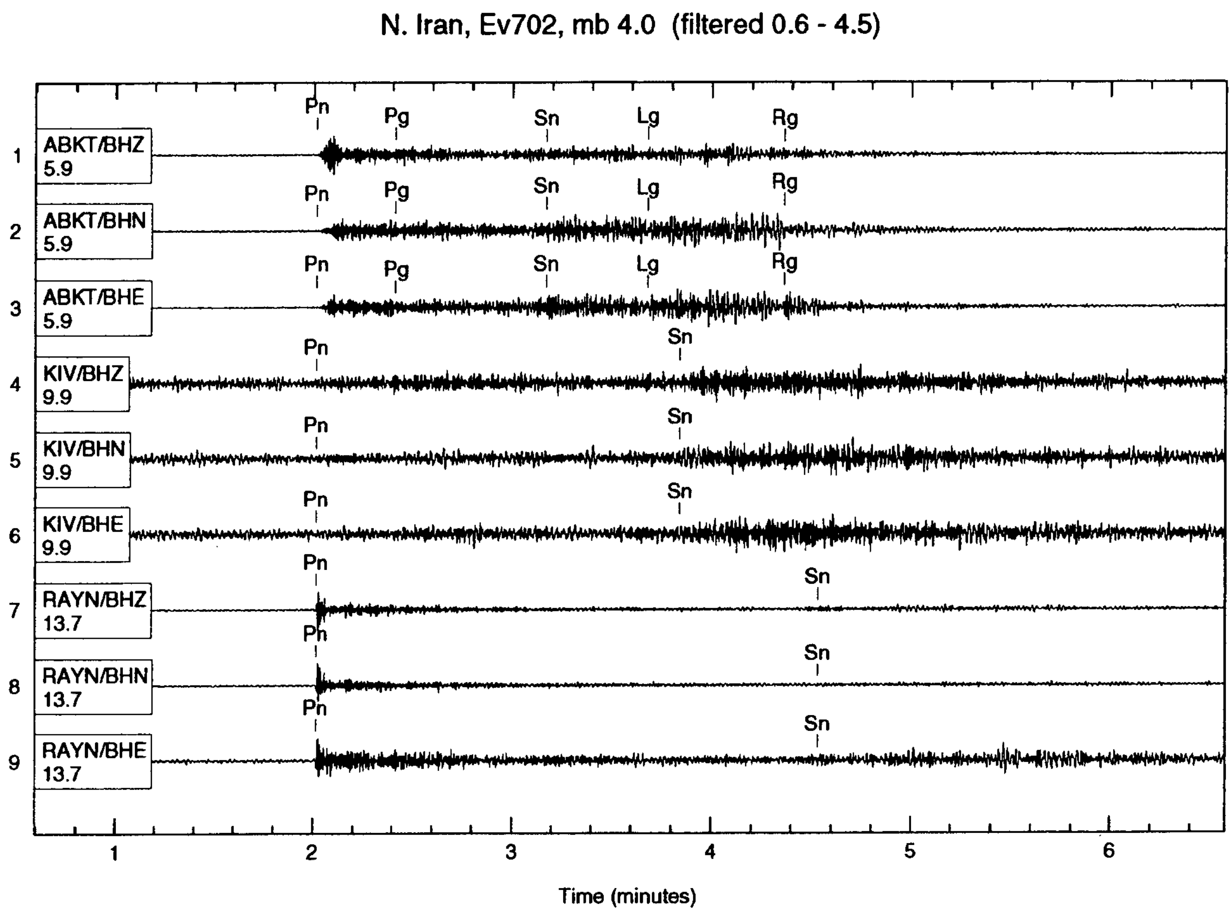
Time scale: one unit = two minutes.

Figure 64: Events 654 and 650 from the N. Turkey region. For both events, three components are shown at two Saudi stations. All traces aligned on first predicted P (plotted below waveforms). All traces are filtered at 0.5 - 2.0 Hz. Note the short period phase labelled Sx was observed for both events.



Time scale: one unit = one minute.

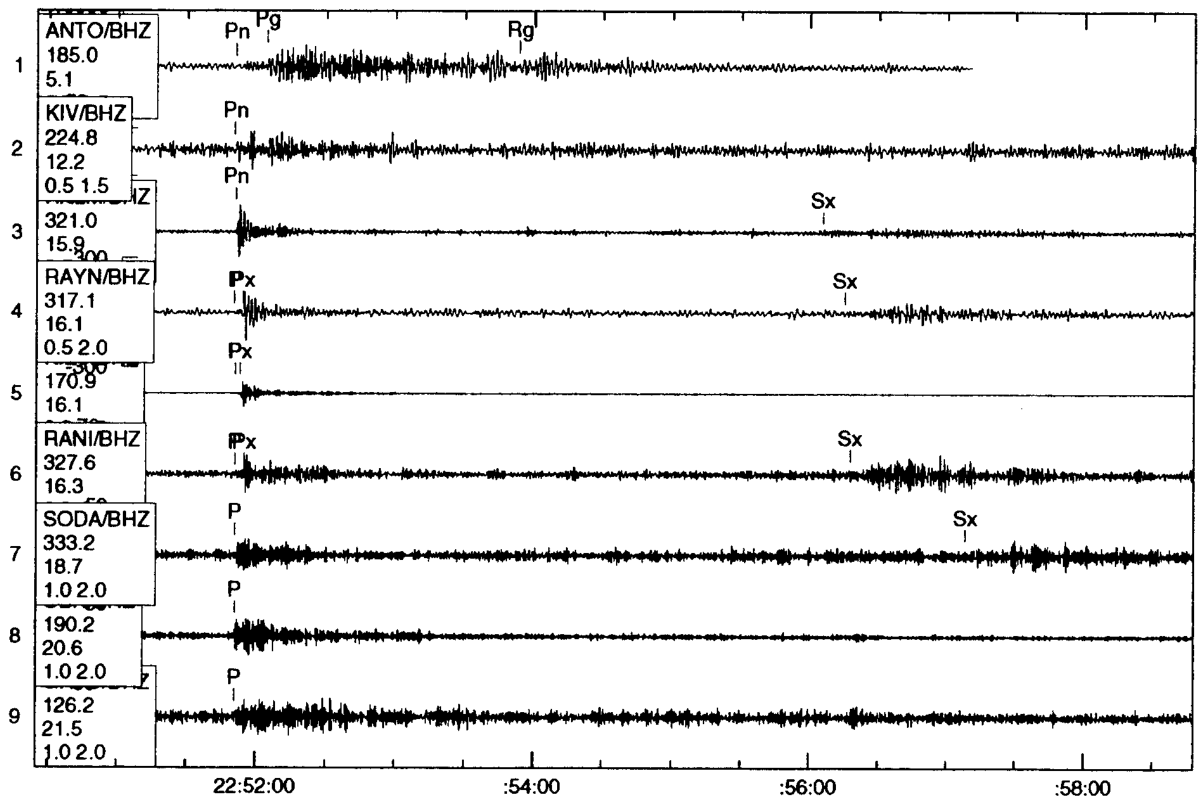
Figure 65: Event 707 from the N. Iran region. Event 707 is nearly equidistant to NIL (13.5 degrees) and KIV (13.8 degrees). No Sn was observed at NIL and no Lg was observed at KIV. All traces are bandpass filtered at 0.01 - 6.0 Hz.



Time scale: five units = one minute.

Figure 66: Event 702 from the N. Iran region. This event is located just south of the Caspian sea. Traces are shown from three 3-C stations: ABKT at 6 degrees distance; KIV at 10 degrees, and RAYN at 13.7 degrees. All traces are filtered at 0.6 - 4.5 Hz and aligned on the Pn arrival.

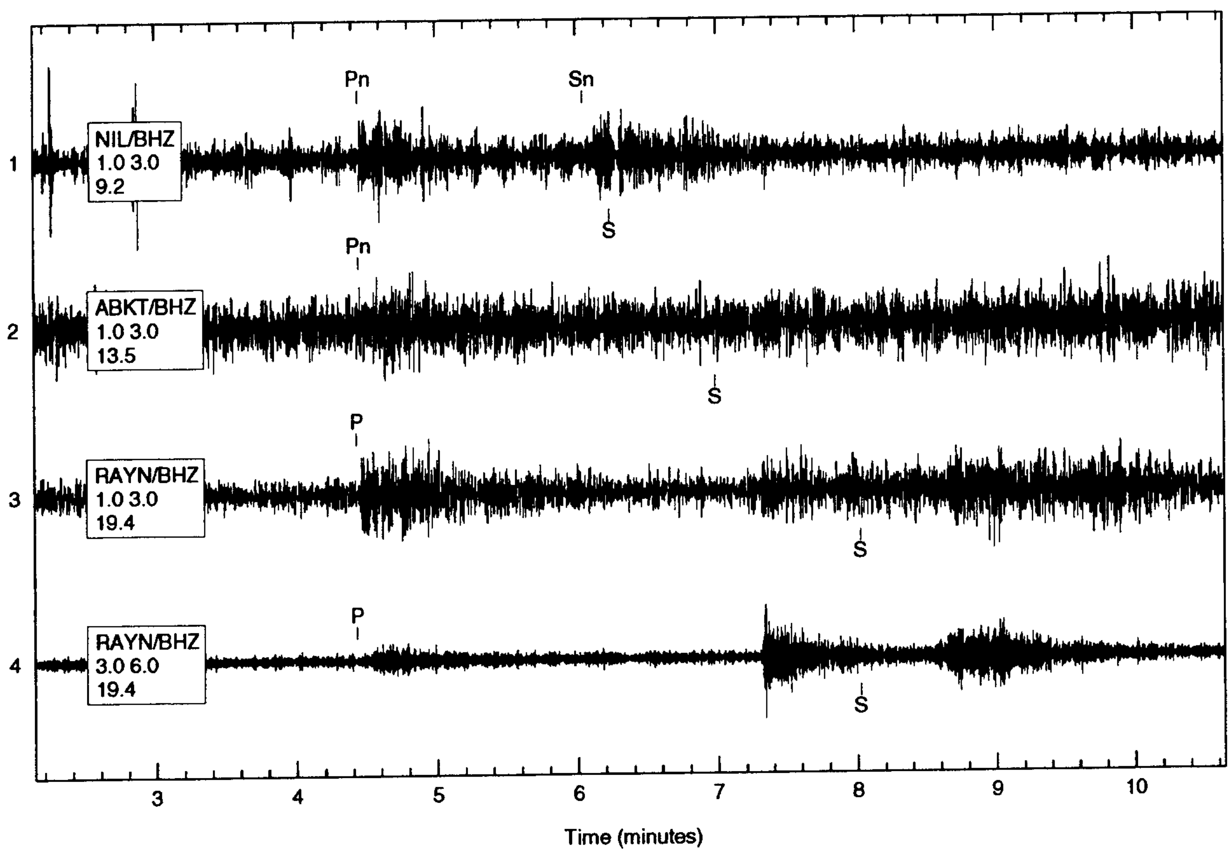
Ev 753 Lat 34.8 Lon 32.3 mb 4.3 h=33 Km



Time scale: two units = one minute.

Figure 67: Event 753 from the E. Mediterranean region. This is the largest event in the E. Mediterranean cluster. Traces are shown from nine stations, including 4 from the Saudi Network. Traces are: ANTO, 0.5 - 1.5 Hz; KIV, 0.5 - 1.5 Hz; HALM, 0.5 - 2 Hz; RAYN, 0.5 - 2 Hz; KIEV, 0.8 - 1.8 Hz; RANI, 0.8 - 1.8 Hz; SODA, 1 - 2 Hz; OBN, 1 - 2 Hz; GRFO, 1.0 - 2.0 Hz. Distances are between 5.1 and 21.5 degrees. Note generic phase labels Px and Sx.

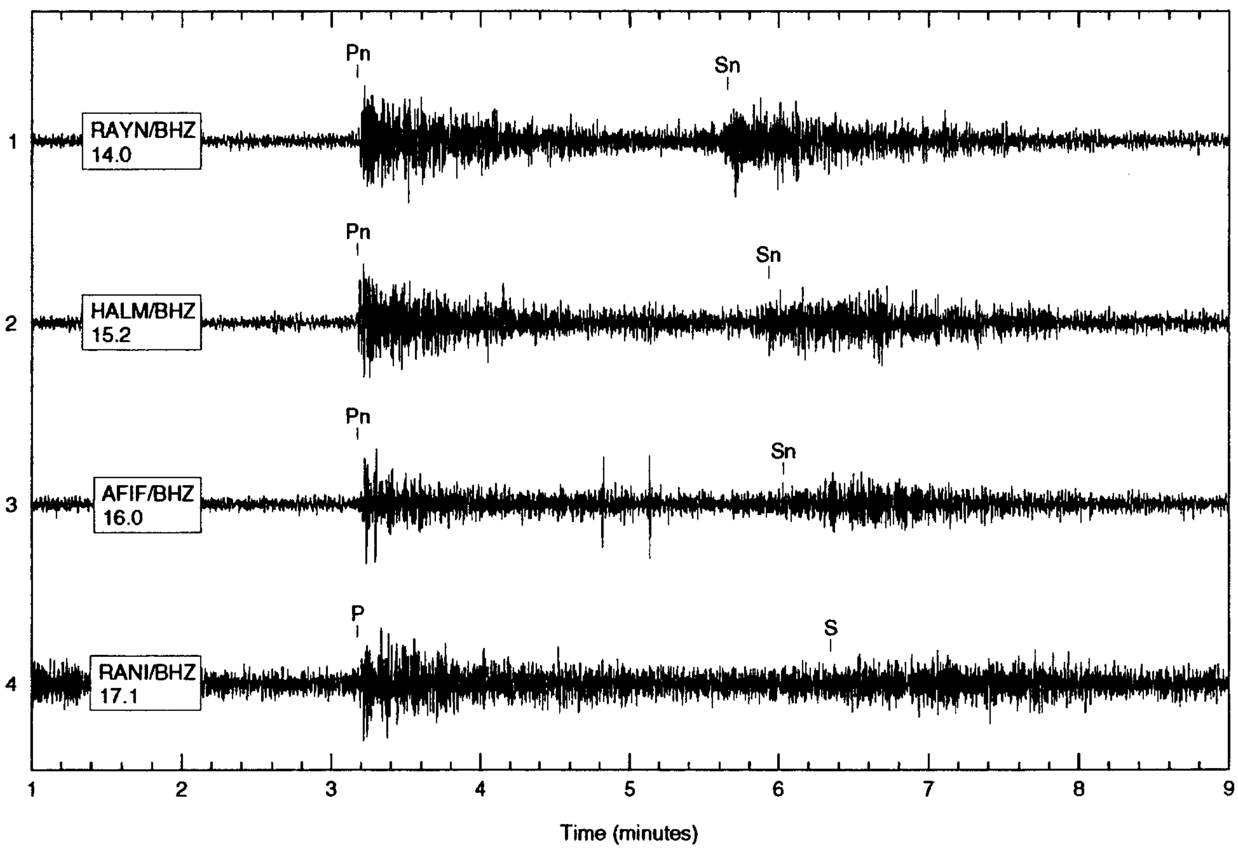
SW Pakistan, Ev852, mb 3.8 (filtered as noted)



Time scale: five units = one minute.

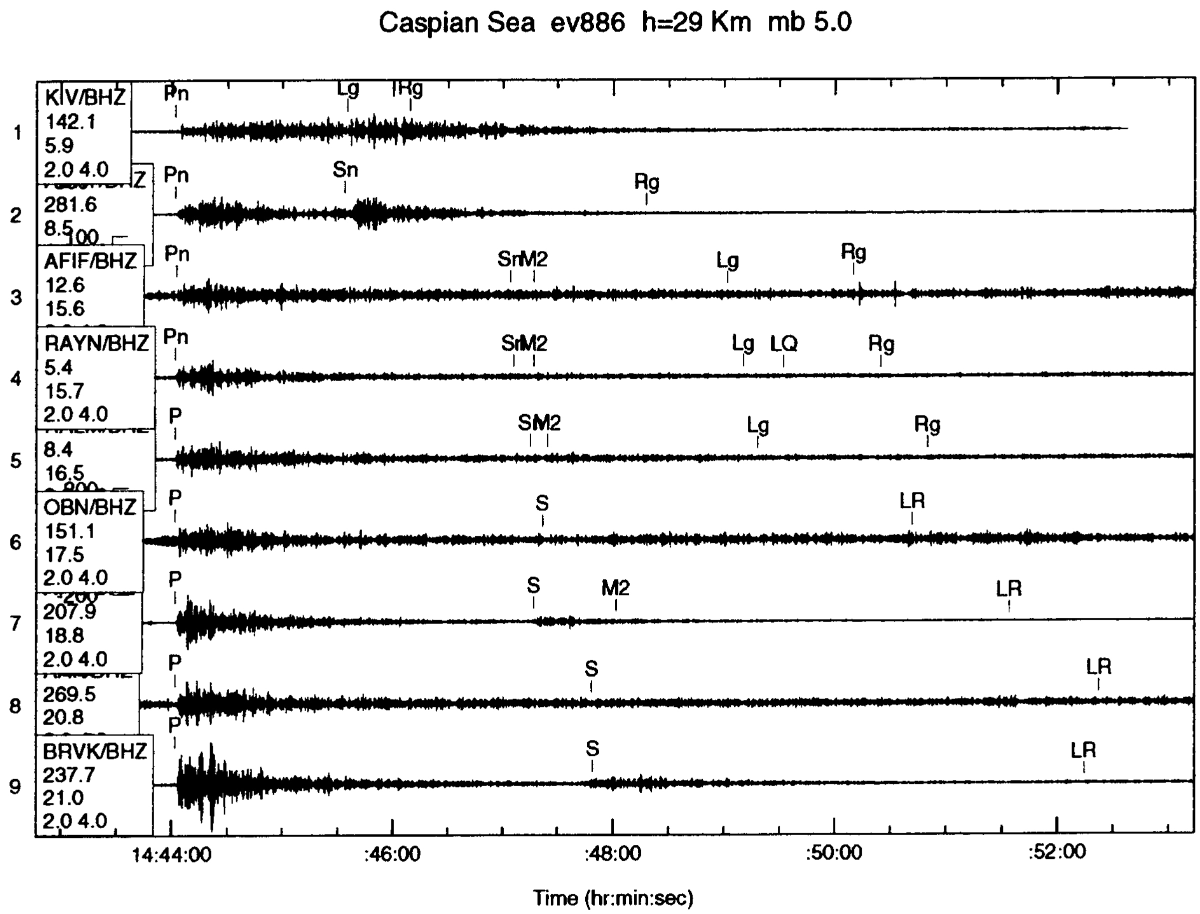
Figure 68: Event 852 from the SW Pakistan region. Vertical traces from three stations are shown: NIL at 9.2 degrees, ABKT at 13.5 degrees, and RAYN at 19.4 degrees. These three traces are filtered at 1 - 3 Hz. The fourth trace is filtered at 3 - 6 Hz to show a near regional event that records about the time of the expected S at RAYN. Theoretical S arrival times are plotted below each trace.

SW Pakistan, Ev857, mb 3.8 (filtered 0.6 - 4.5)



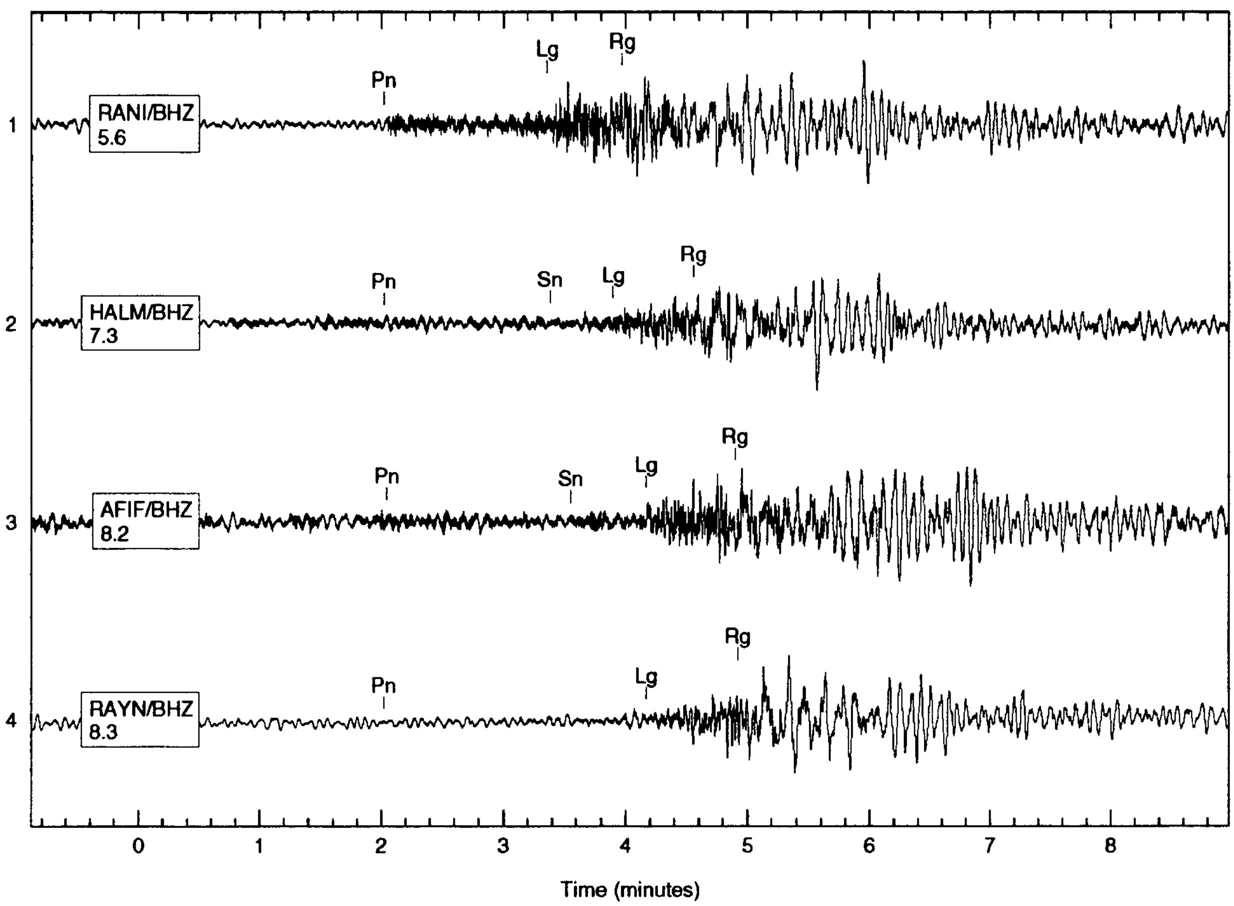
Time scale: five units = one minute.

Figure 69: Event 857. Although event 857 is grouped with events in the SW Pakistan cluster, it is actually located in SE Iran. Vertical traces from four stations in the Saudi Network are shown. Distance ranges are between 14 and 17.1 degrees. All traces are filtered at 0.6 - 4.5 Hz. No Lg was observed along this path. Based on differences between observed and theoretical arrival times, the USGS(PDE) location for this event appears to be off by about 0.4 degrees.



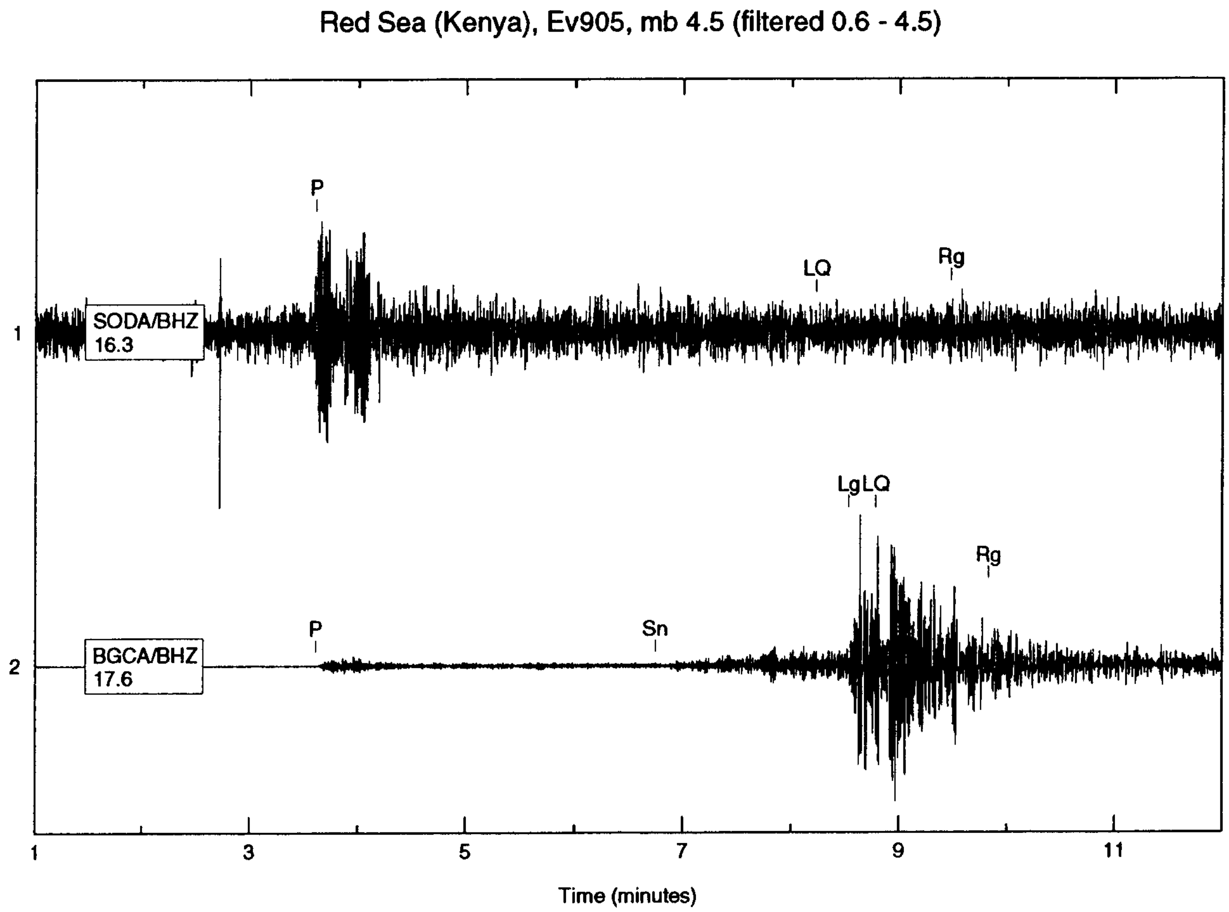
Time scale: five units = one minute.

Figure 70: Event 886 from the Caspian region. Vertical traces from 9 stations are shown, including three from the Saudi Network. Distance ranges are between 5.9 and 21 degrees. Traces are filtered at 2 - 4 Hz. Note the intermediate-period surface wave labelled M2.



Time scale: five units = one minute.

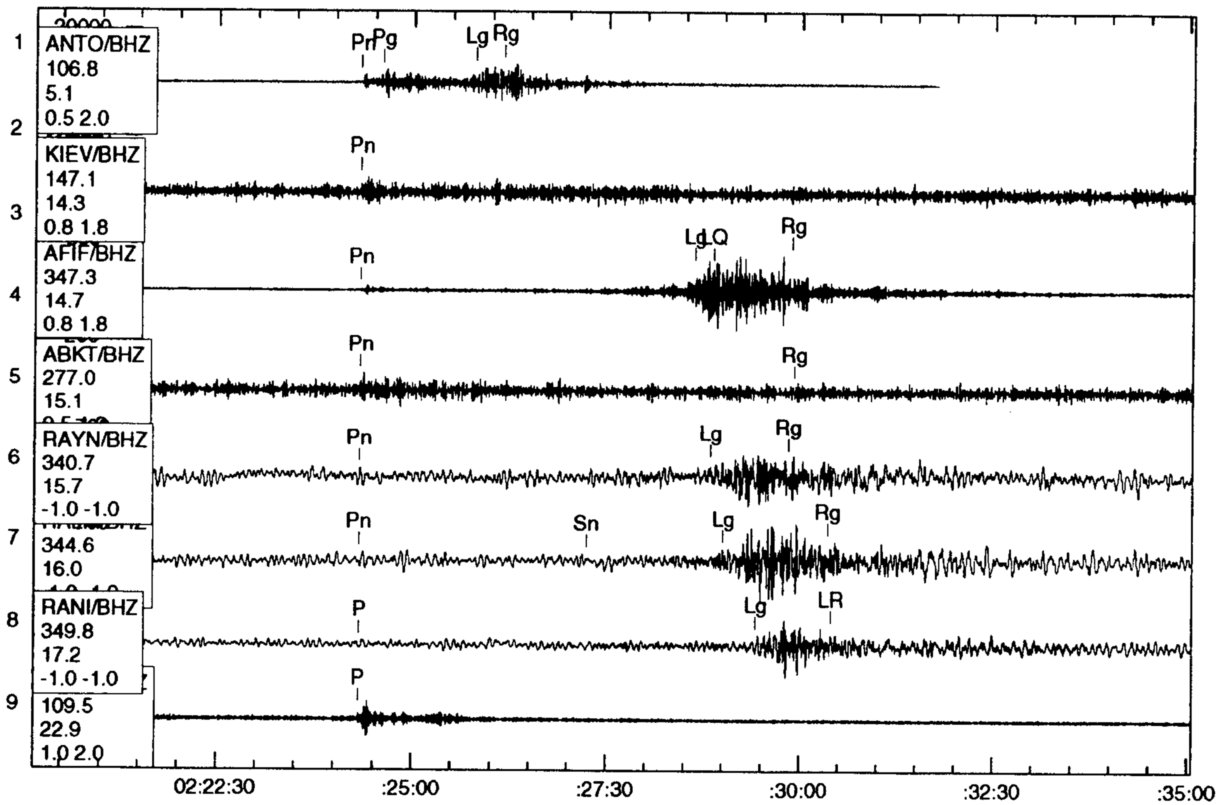
Figure 71: Event 906 from the Red Sea region. This is one of the events clustered in the Red Sea, due south of the Saudi station SODA. Vertical traces from four stations of the Saudi Network are shown. Distance ranges are between 5.6 and 8.3 degrees. Traces are unfiltered.



Time scale: one unit = one minute.

Figure 72: Event 905 from the Red Sea region. This event is located in Kenya. It is not shown in Figure 52. Vertical traces are shown for station BGCA and Saudi station SODA. Both traces are filtered at 0.6 - 4.5 Hz. Station SODA is about 16.3 degrees from the event with a back azimuth of 203 degrees. Station BGCA is about 17.6 degrees from the event with a back azimuth of about 96 degrees.

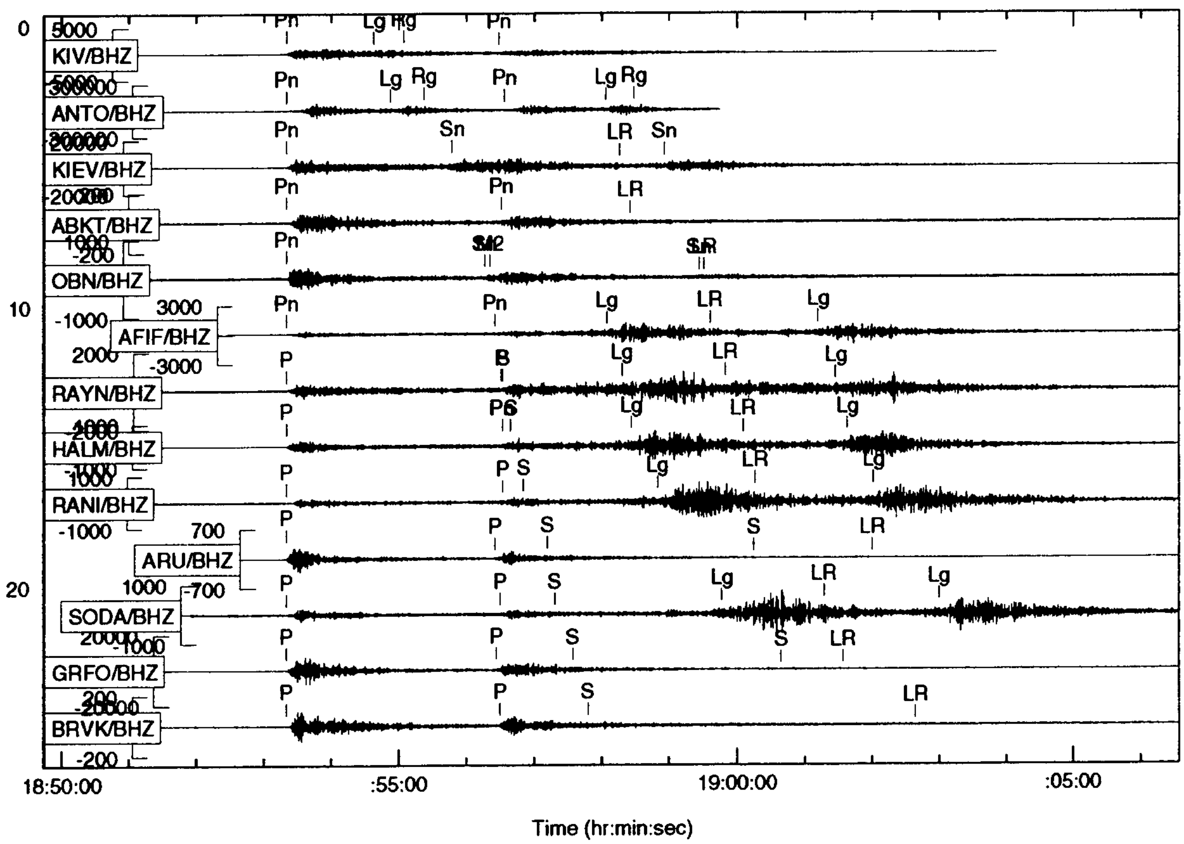
Ev963 mb 3.8



Time scale: two units = one minute.

Figure 73: Event 963 from the E. Turkey region. Traces are shown from 8 stations, including 3 from the Saudi Network. Distances ranges are between 5.1 and 22.9 degrees. Traces are filtered as follows: ANTO, 0.5 - 2.0 Hz; KIEV, 0.8 - 1.8 Hz; AFIF, 0.8 - 1.8 Hz; ABKT, 0.5 - 1.3 Hz; RAYN, unfiltered; HALM, unfiltered; RANI, unfiltered; GRFO, 1-2 Hz. Note the well-recorded Lg arrivals at Saudi stations.

Ev951 mb 5.5, Ev952 mb 5.3



Time scale: one unit = one minute.

Figure 74: Events 951 and 952 from the E. Turkey region. Traces are shown from 13 stations, including four from the Saudi Network. Distance ranges are between 4.9 and 24.6 degrees. All traces are filtered at 1 - 4 Hz. These are the two largest events in this cluster and they occur 3m 7s apart. Note mixed coda signals at all stations.

Chapter 7

The REB EQ Dataset

The REB EQ Dataset comprises 125 events which occurred in the Middle East and North Africa (ME-NA) during 1996 and 1997. Tight spatial and temporal clustering of events suggests these are all aftershock sequences or swarms.[39]

Event parameters are based on the Reviewed Event Bulletin (REB) produced by the Prototype International Data Center (pIDC). The eight clusters are located in: Cyprus, Ethiopia, N. Iran, Pakistan, Hormuz, S. Iran, Spain, and Turkmenistan. Waveform data were retrieved from the pIDC, USGS, and IRIS Data Management Center (DMC) archives. The complete dataset consists of over 710 MB of waveform and parameter data in the form of compressed unix tar event directories. Uncompressed, this dataset takes up almost 1.5 Gigabytes of disk space.

Construction of the REB EQ Event Directories

Event lists were compiled after identifying sequences of aftershocks or swarms in the ME-NA region while scanning the Reviewed Event Bulletin (REB) on a regular basis during 1996 and 1997. Using the ReqData program, data requests were then made from both the pIDC and USGS archives for stations mostly within about 50 degrees distance.

Additional data requests were later made to the IRIS DMC using a modified version of ReqData which submits IRIS Breq_Fast requests. After IRIS completed the requests, the data were FTP'd to our machine and converted to CSS3.0 format using IRIS's **rdseed** program (version 4.21).

Included in our IRIS requests were the following stations: AAE, ABKT, ARU, BRVK, CMLA, EIL, GNI, KIV, NIL, OBN, RAYN, and 10 stations from the Kyrgyzstan (KNET) network (AAK, AML, CHM, EKS2, KBK, KZA, TKM2, UCH, ULHL, USP). We requested segments starting 3 minutes before P and extending to twice the expected LR time. A time delay of 2-3 months or more was often required before data became available from stations in the DMC archive.

[39] A general definition of an aftershock sequence put forth by Hough and Jones (1997) is "any earthquake that occurs within one fault rupture length of its mainshock and during the span of time that the seismicity rate in that region remains above its pre-mainshock background level". A strict application of this definition may not be appropriate. Further study (e.g., relocation of the events with more data) may yield a revised list of events in each cluster.

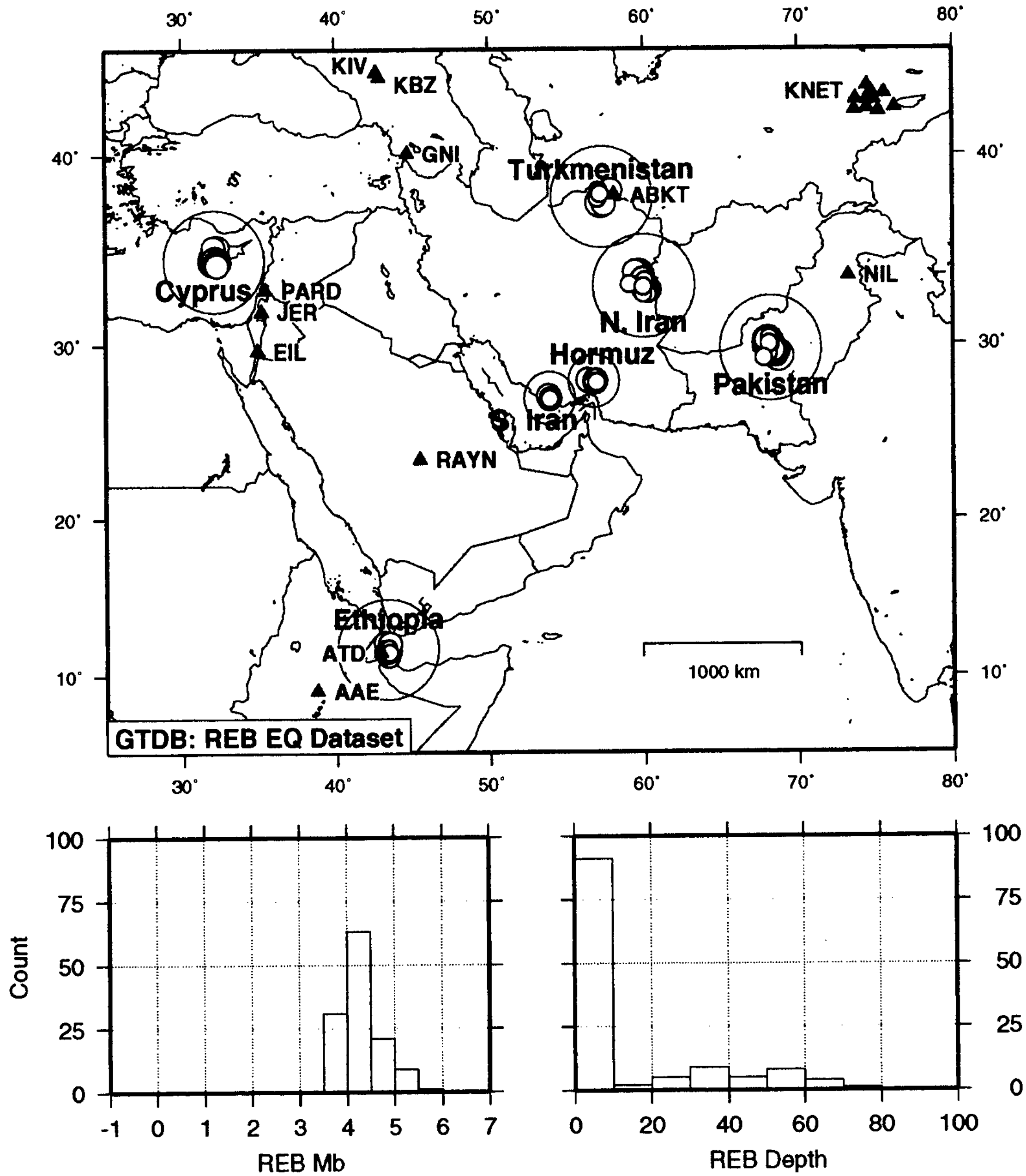


Figure 75: The REB EQ Dataset. Tight spatial and temporal clustering of events suggests these are all aftershock sequences or swarms. Event parameters are based on the Reviewed Event Bulletin (REB) produced by the Prototype International Data Center (pIDC). The eight clusters are located in: Cyprus, Ethiopia, N. Iran, Pakistan, Hormuz, S. Iran, Turkmenistan, and Spain (not shown).

Interactive Waveform Analysis

The main feature of this dataset is the high-quality, consistent seismic waveform analysis that accompanies each event. This information is distributed with the event directories in the form of CSS3.0 database tables (*arrival*, *assoc*, *remark*). A total of 1,924 phases are associated with the 125 events in this dataset.

Events were reviewed in clusters rather than chronologically. This approach results in consistent analysis in which an understanding of one event can be applied to nearby events. Another factor lending to consistent analysis is that it was completed by one person, Bob Wagner. Arrivals were identified and timed carefully, but no amplitudes or periods were measured.

LQ and LR onset times were picked as early as possible, usually with low-frequency filters. LR was picked on the vertical component, and LQ was usually timed on the most transverse horizontal component. Horizontal channels were not usually rotated due to sporadic performance of the rotate function in **geotool**. In general, LQ and LR are unreliable for travel time curve determination.

After completing all events for a region, those events were reviewed as a group on a path by path basis. Using **geotool**, all traces pertaining to one station were displayed and aligned based on waveform similarity. Using this method of review, it was possible to retime some of the arrivals and make sure that the phase names were consistent. In doing this simultaneous review, no arrivals were picked for phases that were not visible to the analyst.

For the REB EQ dataset, we chose to include only events which were recorded at one or more stations. If no arrivals were picked on the data we collected for a given event, then the event was rejected and not saved in the database. Waveform data for most stations were retained in the database regardless of signal quality, and some of the waveforms included may not have arrivals picked.

The results of analysis are summarized in the bar plots in Figure 76. The total number of events in each cluster and the total number of associated phases for each cluster are listed at left. Bars show the distribution of associated arrivals by phase type. This display summarizes where the different phase types were observed by the analyst. For example, P was observed more often than Pg in the Cyprus cluster, Pg was not observed in the Hormuz cluster, few regional phases were observed from the Hormuz cluster, and the phase type predominantly observed from the Turkmenistan cluster was Sn.

In the following discussions of each cluster, event parameters (*e.g.* mb) are from the REB unless otherwise noted in the text.

The Cyprus Cluster

Of the 28 events selected for this cluster, all but three occurred between 9 October 1996 and 12 October 1996, with one-half the events (14) occurring on 9 October 1996. REB magnitudes ranged from mb 4.02 to 5.84.

The REB bulletin reported the main shock, ev6000 on 9 October 1996 at 13:10:56.571 GMT, to have mb 5.84 and depth of 59 km. Therefore, regional arrivals were considered

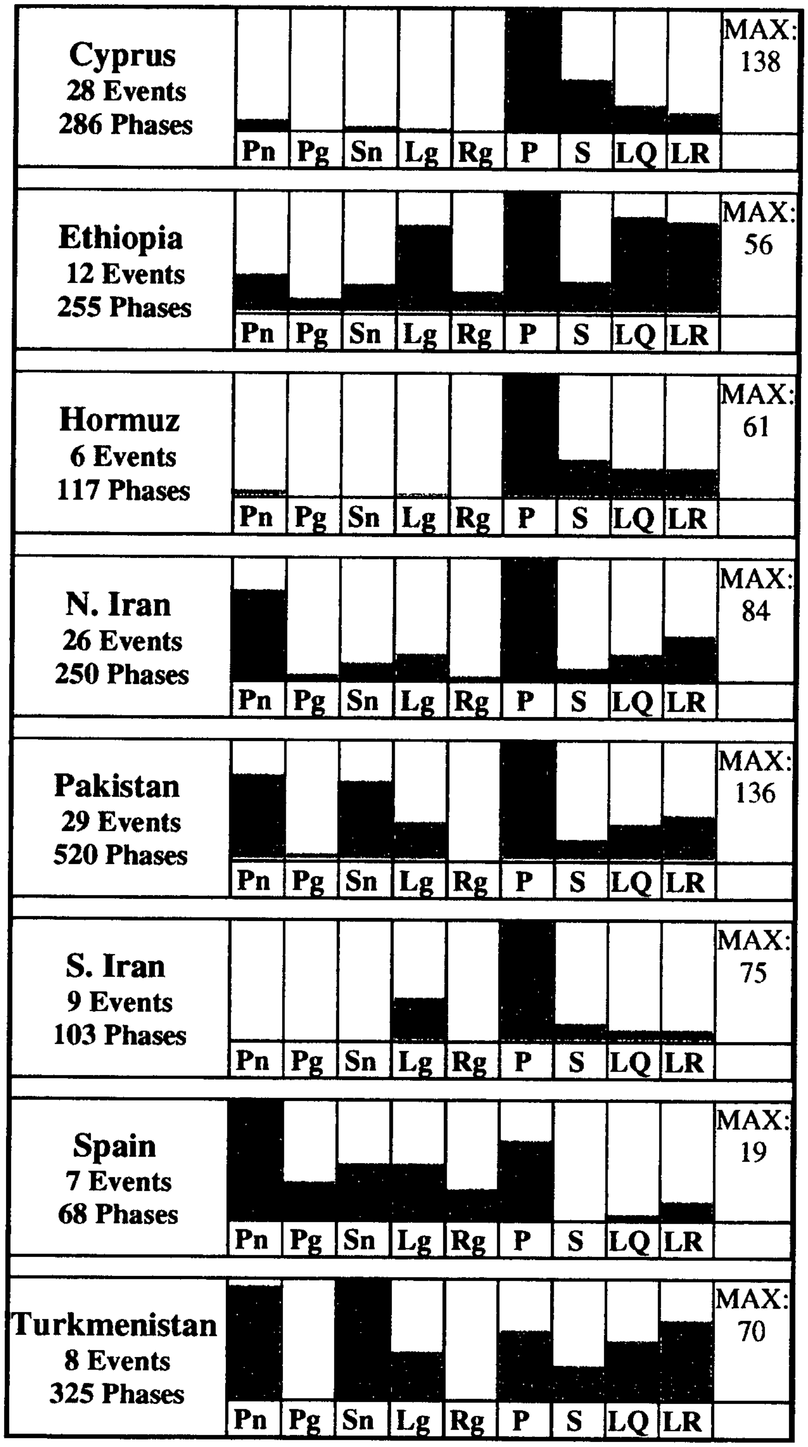


Figure 76: Summary of results by cluster and phase type. The total number of events in each cluster and the total number of associated phases for each cluster are listed at left. Bars show the distribution of associated arrivals by phase type. Within each cluster, bar heights are scaled to the maximum number of associated arrivals, which is listed on the right side of the figure.

as deep phase types at least for the main shock, although several stations recorded surface waves LQ and LR. Most events (15) were restricted to a depth of 0 km, and overall, depths ranged from 0 km to 74.7 km. Two events (ev6026 and ev6027) recorded strong Lg's at BGCA (32 degrees).

According to REB locations, all the events were within 0.6 degrees (about 70 km) of the main event (ev6000), with 80 percent of them at less than 0.3 degrees (30 km).

Sample plots are shown in Figures 77 and 78, on pages 149 and 150.

The Ethiopia Cluster

The Ethiopia group comprises 12 events located offshore, near Djibouti in the Gulf of Tadjoura. All the events occurred on 9 and 10 March 1997. Magnitudes of these events in the USGS Weekly HDF are between mb 3.8 and 5.0. Waveforms from these events appear to be very similar, suggesting the events are from very nearly the same source region.

Sample plots are shown in Figures 79 through 81. Figure 81, on page 153, shows an example of strong Pg and Lg crustal phases observed at nearly 12 degrees distance.

The N. Iran Cluster

This cluster of 26 events in northern Iran (near 33N 60E) occurred between 10 May 97 and 16 Jun 97, with the main shock (ev7100, mb 5.37) at 07:57:29 GMT on 10 May 97. Most events (21) occur on 10 May 97, and numerous aftershocks may be observed within minutes of each other. Magnitudes ranged from mb 3.7 to 5.4, and depths from the surface to 65 km with most (22) restricted to zero.

Of the 16 stations at which arrivals were picked, seven (AAK, ABKT, GNI, KIV, KBZ, NIL, and RAYN) recorded crustal phases at regional distances.

Examples of analysis observations are shown in Figures 82 through 84.

The Pakistan Cluster

This cluster comprises 29 events in central Pakistan (near 30N 68E). The events occurred between 27 Feb 97 and 22 Mar 97, with the main shock (ev7051, mb 5.45) at 21:08:04.7 on 27 Feb 97. Most events (22) occurred on the first two days, and numerous aftershocks may be observed within minutes of each other. Magnitudes ranged from mb 3.7 to 5.4, and depths from the surface to 65 km with slightly more than half (17) restricted to zero. Although some events are listed as deep in the REB, strong crustal phases were often observed at NIL.

Of the 27 stations at which arrivals were picked, only NIL (Nilore, Pakistan, 5.8 deg) and the 10 station Kyrgyzstan network (KNET, 14 deg) recorded regional phases. All other stations were teleseismic ranging from 21 degrees (RAYN) to 75 degrees distance.

The main shock is shown at KNET stations in Figure 85, on page 157. Other sample plots are shown in Figures 86 through 89.

The Hormuz Cluster

A small cluster of 6 events in southern Iran (near 27.9N 56.8E) occurred on 19 Apr 1997 with the main shock (ev7150, mb 4.8, depth 52.6 km) occurring at 05:53:18.757 GMT. Magnitudes ranged from mb 3.8 to 4.8, and depths from the surface to 52.6 km. REB depths for three events were restricted to zero.

Of the 23 stations at which arrivals were picked, six are within 20 degrees distance (AML, EIL, JER, KIV, NIL, and PARD). The nearest station is NIL at 15 degrees. The remaining 17 stations are at teleseismic distances ranging from 20 degrees (UCH) to 62 degrees (DBIC). Only 3-component stations with broadband or short-period channels were retrieved.

The main shock is shown at KNET stations in Figure 91, on page 163. Other observations are shown in Figures 90 and 92.

The S. Iran Cluster

All nine events in this group occurred on 5 May 1997 with the largest event (ev7162, mb 4.53) following two earlier events. The tight spatial and temporal distribution (all events are within 0.3 degrees or 35 km of each other) indicates that this sequence is an aftershock series or swarm. Magnitudes ranged from mb 3.63 to 4.53 (REB), and depths from the surface to 53 km. Depths for all but two events were restricted to zero in the REB.

Of the 19 stations at which arrivals were picked, four are within 20 degrees (EIL, KBZ, KIV, NIL). The nearest station, EIL at 16.8 degrees, records only one event (ev7160). The 15 teleseismic stations range in distance from 22 degrees (AML) to 59 degrees (DBIC).

The main shock is shown at KNET stations in Figure 95, on page 167. Other sample plots from this cluster are shown in Figures 93 and 94.

The Spain Cluster

This cluster comprises 7 events in Spain near 42.8N 7.2W. The events occurred between 21 May 97 and 23 May 97. Magnitudes ranged from mb 3.6 to 4.5, and all depths were restricted to zero in the REB.

Of the 9 stations at which arrivals were picked, four (ESLA, GEC2, DAVOS, VRAC) recorded crustal phases at regional distances. Station ESLA (Sonseca, Spain; distance 4.0 degrees) was available for all but one event (ev179). Sonseca recorded many crustal phase types including Pn, Pb, Pg, Sn, Lg, and Rg. All other stations were teleseismic ranging from 36.0 degrees (EIL) to 61.6 degrees (NIL).

Regional observations from a sample event are shown in Figure 98, on page 170. Additional sample plots are shown in Figures 96 and 97.

The Turkmenistan Cluster

This cluster of 8 events is located in southern Turkmenistan along the Iran border (near 37.8N 57.3E). The events occurred between 4 Feb 1997 and 6 Feb 1997, with the the largest

event (ev7022, mb 5.31) following the earliest (ev7021, mb 4.98) by about 44 minutes. Five of the selected events occurred on 4 Feb 1997. Magnitudes ranged from mb 3.5 to 5.3, and all depths were restricted to zero.

Of the 25 stations at which arrivals were picked, 16 are within a regional distance range of less than 20 degrees, including 9 stations of the Kyrgyzstan network (KNET) and 7 others (ARU, BRVK, GNI, JER, KBZ, KIV, NIL). The remaining 9 stations are teleseismic ranging from a distance of 20 degrees (EIL) to 64 degrees (DBIC). Only 3-component stations with broadband or short-period channels were retrieved.

Regional observations from a sample event are shown in Figure 99, on page 171. Figures 100 through 102 illustrate other observations.

Event Lists

In the event listings that follow, the origin time, latitude, longitude, depth, and mb are defined by the Reviewed Event Bulletin (REB) of the pIDC.

The parameter, ndef, represents the number of defining phases used to define the event. The parameter, nass, is the number of GTDB phases associated with the event. For some of the events in the REB EQ dataset, nass is a bigger number than ndef. This indicates that more phase picks are associated with the event in the GTDB than were associated with the event at the time it was defined in the REB.

The event type field, etype, is "eq" (earthquake) for these events. This is an assumption based on the tight spatial and temporal clustering of these events with respect to major earthquakes listed in the USGS bulletin in each case.

GTDB: REB EQ Dataset: Region: Cyprus

origin time			lat	lon	dep	d	mb	ndef	nass	etype	evid	author
1996283	10/09/1996	13:10:56.571	34.64	32.15	59	f	5.8	42	43	eq	6000	REB
1996283	10/09/1996	13:27:21.145	34.97	32.24	0	g	4.3	16	3	eq	6001	REB
1996283	10/09/1996	13:48:19.583	34.43	32.03	0	g	4.2	16	3	eq	6002	REB
1996283	10/09/1996	13:55:22.458	34.46	32.20	0	g	4.2	14	4	eq	6003	REB
1996283	10/09/1996	14:00:10.608	34.54	32.06	23	f	5.0	36	8	eq	6004	REB
1996283	10/09/1996	14:50:42.617	34.60	32.11	0	g	4.2	13	3	eq	6005	REB
1996283	10/09/1996	14:56:18.542	34.52	32.11	0	g	4.5	24	5	eq	6006	REB
1996283	10/09/1996	15:09:34.325	34.42	32.28	0	g	4.7	25	7	eq	6007	REB
1996283	10/09/1996	16:22:34.609	34.53	32.27	0	g	5.0	26	7	eq	6008	REB
1996283	10/09/1996	17:01:51.660	35.26	32.32	0	g	4.1	6	2	eq	6009	REB
1996283	10/09/1996	19:10:55.673	34.55	32.14	0	g	4.6	25	12	eq	6010	REB
1996283	10/09/1996	19:38:21.271	34.73	32.18	0	g	4.2	17	4	eq	6011	REB
1996283	10/09/1996	19:45:22.711	34.47	32.43	0	g	4.1	8	3	eq	6012	REB
1996283	10/09/1996	14:19:39.741	34.57	32.17	38	f	5.2	42	11	eq	6013	REB
1996284	10/10/1996	0:33:23.266	34.62	32.09	61	f	4.0	24	9	eq	6014	REB
1996284	10/10/1996	0:23:44.635	34.57	32.12	60	f	4.6	31	10	eq	6015	REB
1996284	10/10/1996	1:10:26.525	34.65	32.08	51	f	5.0	45	26	eq	6016	REB
1996284	10/10/1996	4:54:49.843	34.57	32.06	65	f	4.6	29	12	eq	6017	REB
1996283	10/09/1996	19:58:27.999	34.56	32.17	0	g	4.6	24	10	eq	6018	REB
1996284	10/10/1996	9:04:00.006	34.62	32.15	34	d	4.3	34	6	eq	6019	REB
1996285	10/11/1996	1:39:55.930	34.65	32.15	0	g	4.5	20	10	eq	6020	REB
1996285	10/11/1996	8:13:47.932	35.22	32.05	75	f	4.1	18	5	eq	6021	REB
1996286	10/12/1996	11:04:39.505	34.65	32.18	40	d	4.2	31	9	eq	6022	REB
1996286	10/12/1996	15:06:13.196	34.49	32.21	0	g	4.2	15	3	eq	6023	REB
1996286	10/12/1996	17:50:24.478	34.48	32.27	0	g	4.5	24	7	eq	6025	REB
1996332	11/27/1996	0:44:25.751	34.59	32.05	37	d	4.7	52	22	eq	6026	REB
1996337	12/02/1996	4:08:47.806	34.44	32.23	13	f	4.7	29	15	eq	6027	REB
1997013	1/13/1997	10:19:28.109	34.27	32.30	37	f	4.9	36	25	eq	6028	REB

GTDB: REB EQ Dataset: Region: Ethiopia

origin time			lat	lon	dep	d	mb	ndef	nass	etype	evid	author
1997068	3/09/1997	1:32:10.909	11.32	43.38	0	r	4.2	9	24	eq	7000	REB
1997068	3/09/1997	2:02:01.796	11.80	43.40	0	g	4.0	15	16	eq	7001	REB
1997068	3/09/1997	3:37:29.286	11.75	43.19	0	g	4.0	10	18	eq	7002	REB
1997068	3/09/1997	13:34:14.278	11.67	43.38	14	d	4.2	17	31	eq	7003	REB
1997068	3/09/1997	17:26:02.171	11.78	43.37	0	g	4.0	10	13	eq	7004	REB
1997068	3/09/1997	17:40:18.299	11.76	43.37	0	g	4.5	24	36	eq	7005	REB
1997068	3/09/1997	17:41:45.238	11.66	43.45	0	g	4.6	21	8	eq	7006	REB
1997068	3/09/1997	19:09:29.772	11.57	43.23	0	g	4.3	27	34	eq	7007	REB
1997069	3/10/1997	0:26:24.721	12.14	43.15	0	g	4.2	3	14	eq	7008	REB
1997069	3/10/1997	7:33:34.559	11.62	43.31	0	g	4.1	10	24	eq	7009	REB
1997069	3/10/1997	8:50:09.076	11.50	43.42	0	g	4.0	10	16	eq	7010	REB
1997069	3/10/1997	9:40:38.682	12.08	43.47	0	g	4.0	4	21	eq	7011	REB

GTDB: REB EQ Dataset: Region: N Iran

origin time			lat	lon	dep	d	mb	ndef	nass	etype	evid	author
1997130	5/10/1997	7:57:29.062	33.73	59.66	0	g	5.4	57	30	eq	7100	REB

1997130	5/10/1997	8:37:14.363	32.90	60.05	0	g	4.1	19	5	eq	7101	REB
1997130	5/10/1997	8:40:23.771	32.75	59.98	0	g	4.0	12	3	eq	7102	REB
1997130	5/10/1997	9:19:31.917	33.60	59.91	0	g	4.2	24	7	eq	7103	REB
1997130	5/10/1997	9:33:30.927	33.21	59.06	0	g	3.8	10	3	eq	7104	REB
1997130	5/10/1997	10:19:52.974	32.93	60.36	0	g	4.0	16	4	eq	7105	REB
1997130	5/10/1997	10:27:29.180	33.71	59.93	65	f	4.0	24	8	eq	7106	REB
1997130	5/10/1997	10:34:20.413	33.35	60.10	0	g	4.0	22	5	eq	7107	REB
1997130	5/10/1997	11:16:17.484	33.01	60.04	0	g	3.8	10	3	eq	7108	REB
1997130	5/10/1997	12:23:07.987	33.09	60.12	0	g	4.2	18	6	eq	7109	REB
1997130	5/10/1997	13:26:39.157	32.99	60.14	38	f	4.0	26	8	eq	7110	REB
1997130	5/10/1997	14:04:35.685	33.03	60.16	0	g	4.2	28	7	eq	7111	REB
1997130	5/10/1997	15:45:04.054	32.74	60.31	0	g	3.8	12	3	eq	7112	REB
1997130	5/10/1997	15:53:27.846	33.40	60.07	0	g	3.9	14	3	eq	7113	REB
1997130	5/10/1997	17:32:43.670	33.46	59.92	0	g	4.2	25	7	eq	7114	REB
1997130	5/10/1997	19:51:38.736	32.91	60.37	0	g	4.1	21	6	eq	7115	REB
1997130	5/10/1997	20:01:38.053	32.67	60.26	0	g	3.7	8	3	eq	7116	REB
1997130	5/10/1997	22:13:52.581	33.32	59.94	0	g	4.3	26	9	eq	7117	REB
1997130	5/10/1997	22:24:30.872	32.68	59.96	0	g	3.9	14	4	eq	7118	REB
1997130	5/10/1997	22:52:25.656	33.08	60.00	0	g	3.9	17	8	eq	7119	REB
1997130	5/10/1997	23:35:36.813	33.04	60.10	0	g	4.3	22	8	eq	7120	REB
1997133	5/13/1997	6:11:57.663	33.85	59.44	0	g	4.1	21	9	eq	7121	REB
1997133	5/13/1997	11:42:25.633	33.46	59.93	25	f	4.1	27	25	eq	7122	REB
1997134	5/14/1997	14:14:16.585	32.96	60.24	0	g	4.6	37	27	eq	7123	REB
1997135	5/15/1997	12:48:20.923	32.87	60.23	0	g	4.2	23	20	eq	7124	REB
1997167	6/16/1997	3:00:10.765	33.14	60.09	45	f	4.5	39	29	eq	7125	REB

GTDB: REB EQ Dataset: Region: Pakistan

origin time			lat	lon	dep	d	mb	ndef	nass	etype	evid	author
1997058	2/27/1997	21:08:04.703	29.88	68.12	46	f	5.5	36	74	eq	7051	REB
1997058	2/27/1997	21:27:30.112	29.68	68.21	0	g	4.4	15	4	eq	7052	REB
1997058	2/27/1997	21:30:38.623	29.94	67.96	35	f	5.5	31	41	eq	7053	REB
1997058	2/27/1997	21:44:02.161	29.89	67.91	20	d	4.2	27	7	eq	7054	REB
1997058	2/27/1997	21:47:32.233	29.93	67.97	56	f	4.0	20	6	eq	7055	REB
1997058	2/27/1997	21:52:01.818	30.28	68.08	65	f	4.0	19	6	eq	7056	REB
1997058	2/27/1997	22:00:36.019	29.89	67.88	0	g	4.1	13	8	eq	7057	REB
1997058	2/27/1997	22:12:28.045	29.91	68.16	46	f	3.8	16	5	eq	7058	REB
1997058	2/27/1997	22:17:38.206	29.92	67.96	0	g	4.3	18	7	eq	7059	REB
1997058	2/27/1997	22:36:48.184	29.43	68.04	0	g	3.7	11	4	eq	7060	REB
1997058	2/27/1997	22:42:01.330	29.57	68.35	38	f	4.4	28	10	eq	7061	REB
1997058	2/27/1997	23:39:14.127	29.99	68.09	57	f	3.7	19	6	eq	7062	REB
1997058	2/27/1997	23:54:11.084	29.22	67.76	0	g	4.0	13	6	eq	7063	REB
1997059	2/28/1997	0:36:09.627	29.61	68.65	0	g	4.2	18	6	eq	7064	REB
1997059	2/28/1997	0:58:24.641	29.69	68.37	0	g	4.2	17	6	eq	7065	REB
1997059	2/28/1997	1:04:06.404	29.40	68.57	0	g	4.3	19	9	eq	7066	REB
1997059	2/28/1997	1:46:22.813	29.61	68.22	0	g	4.6	25	13	eq	7067	REB
1997059	2/28/1997	2:11:10.366	29.43	68.19	0	g	4.2	17	8	eq	7068	REB
1997059	2/28/1997	3:17:37.646	29.53	68.59	34	d	4.4	50	16	eq	7069	REB
1997059	2/28/1997	4:59:31.086	29.74	68.03	0	g	4.2	20	7	eq	7070	REB
1997059	2/28/1997	22:14:58.854	29.96	68.05	0	g	4.3	28	8	eq	7071	REB
1997059	2/28/1997	22:58:44.733	29.96	68.11	0	g	4.4	30	13	eq	7072	REB
1997060	3/01/1997	0:42:09.575	29.55	68.35	31	f	4.4	36	18	eq	7073	REB
1997062	3/03/1997	2:28:36.572	29.60	68.49	50	d	4.4	34	46	eq	7074	REB

1997062	3/03/1997	19:42:40.818	29.53	68.18	0	g	4.3	28	38	eq	7075	REB
1997063	3/04/1997	2:49:33.117	29.63	68.32	7	d	4.2	26	25	eq	7076	REB
1997063	3/04/1997	13:03:43.972	29.32	68.70	0	g	5.1	36	51	eq	7077	REB
1997079	3/20/1997	8:50:37.074	30.09	68.00	0	g	5.3	42	44	eq	7078	REB
1997081	3/22/1997	6:19:49.538	30.17	67.92	0	g	4.7	26	28	eq	7079	REB

GTDB: REB EQ Dataset: Region: Hormuz

origin time			lat	lon	dep	d	mb	ndef	nass	etype	evid	author
1997109	4/19/1997	5:53:18.757	27.98	56.88	53	f	4.8	36	64	eq	7150	REB
1997109	4/19/1997	6:06:47.595	27.89	56.71	0	g	3.9	8	8	eq	7151	REB
1997109	4/19/1997	6:34:12.307	28.02	56.40	0	g	4.0	5	3	eq	7152	REB
1997109	4/19/1997	8:51:16.659	27.89	56.92	0	g	3.8	5	2	eq	7153	REB
1997109	4/19/1997	10:10:48.725	27.94	56.85	47	f	4.0	26	21	eq	7154	REB
1997109	4/19/1997	22:31:38.822	27.91	56.82	22	d	4.0	47	20	eq	7155	REB

GTDB: REB EQ Dataset: Region: S Iran

origin time			lat	lon	dep	d	mb	ndef	nass	etype	evid	author
1997125	5/05/1997	13:21:04.677	27.06	53.86	0	g	4.3	19	11	eq	7160	REB
1997125	5/05/1997	13:48:46.528	27.10	53.93	0	g	3.9	9	2	eq	7161	REB
1997125	5/05/1997	15:11:54.994	27.02	53.88	29	f	4.5	35	41	eq	7162	REB
1997125	5/05/1997	15:39:49.842	27.14	53.81	0	g	4.0	14	6	eq	7163	REB
1997125	5/05/1997	15:47:30.514	26.93	53.90	0	g	4.0	16	9	eq	7164	REB
1997125	5/05/1997	16:00:26.180	27.01	53.97	0	g	3.9	13	6	eq	7165	REB
1997125	5/05/1997	16:30:13.812	27.05	53.82	53	f	3.6	11	10	eq	7166	REB
1997125	5/05/1997	16:35:28.980	26.89	54.01	0	g	3.9	9	9	eq	7167	REB
1997125	5/05/1997	16:35:54.017	26.98	53.89	0	g	4.0	17	9	eq	7168	REB

GTDB: REB EQ Dataset: Region: Spain

origin time			lat	lon	dep	d	mb	ndef	nass	etype	evid	author
1997141	5/21/1997	23:49:42.292	42.83	-7.27	0	g	4.5	31	11	eq	175	REB
1997142	5/22/1997	0:02:51.852	42.81	-6.93	0	g	4.2	25	10	eq	176	REB
1997142	5/22/1997	0:17:16.682	42.84	-7.20	0	g	4.5	33	16	eq	177	REB
1997142	5/22/1997	1:32:33.806	42.83	-7.06	0	g	3.8	8	6	eq	178	REB
1997142	5/22/1997	5:06:50.444	42.88	-7.24	0	g	4.0	16	4	eq	179	REB
1997143	5/23/1997	0:39:07.302	42.79	-7.41	0	g	3.6	9	5	eq	180	REB
1997143	5/23/1997	18:14:39.504	42.80	-7.17	0	g	4.4	36	16	eq	181	REB

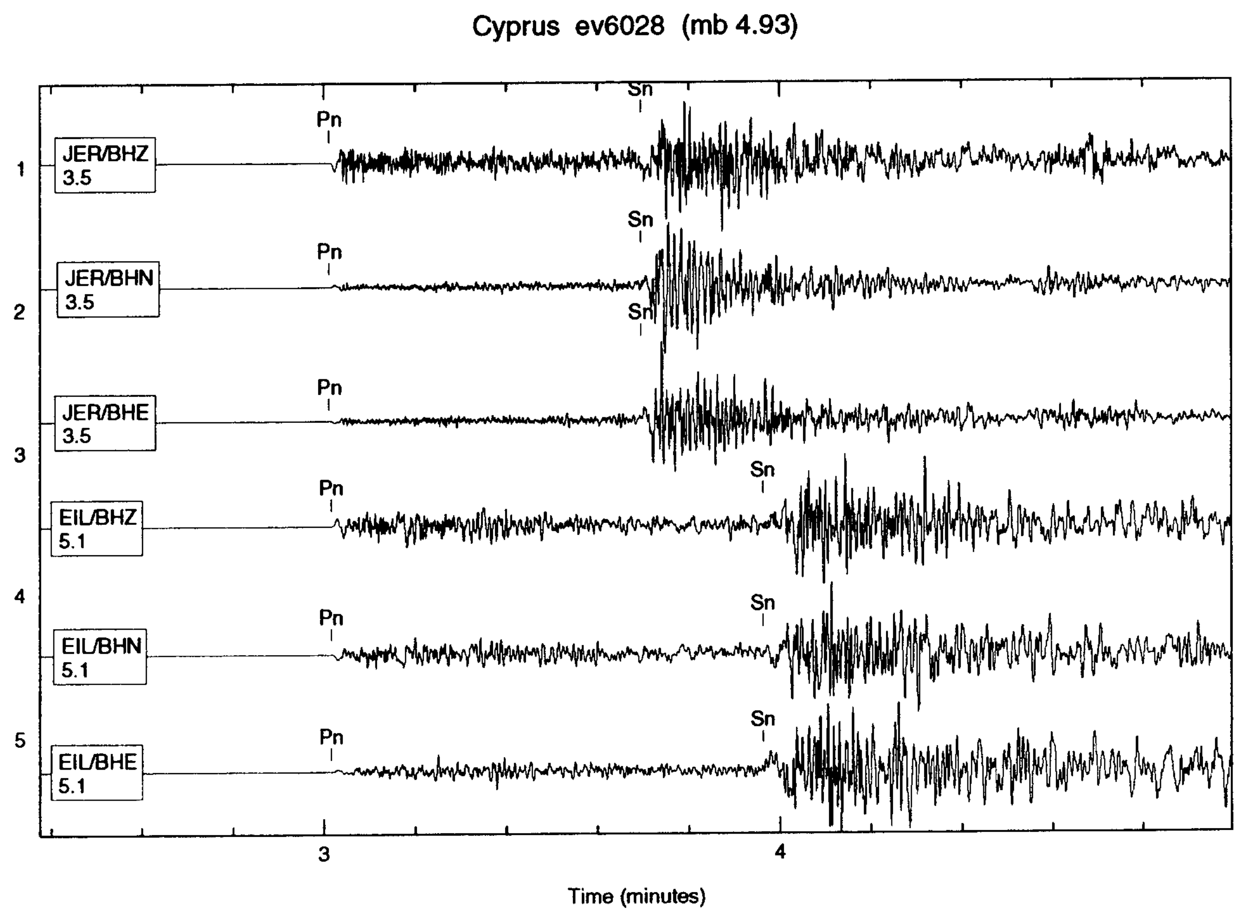
GTDB: REB EQ Dataset: Region: Turkmenistan

origin time			lat	lon	dep	d	mb	ndef	nass	etype	evid	author
1997035	2/04/1997	9:53:56.054	37.67	57.32	0	g	5.0	36	57	eq	7021	REB
1997035	2/04/1997	10:37:46.009	37.53	57.27	0	g	5.3	37	80	eq	7022	REB
1997035	2/04/1997	12:34:58.728	38.16	57.08	0	g	3.9	10	20	eq	7023	REB
1997035	2/04/1997	14:46:56.561	38.18	57.89	0	g	4.1	14	17	eq	7024	REB
1997035	2/04/1997	21:04:09.315	37.75	57.06	0	r	3.9	17	42	eq	7025	REB
1997036	2/05/1997	7:53:44.696	37.46	57.44	0	g	4.8	29	51	eq	7026	REB
1997037	2/06/1997	20:47:49.460	38.02	57.16	0	g	3.5	6	24	eq	7027	REB
1997037	2/06/1997	21:20:38.843	37.98	57.18	0	g	3.8	12	35	eq	7028	REB

Sample Waveform Plots

Plots in this section are representative of the data available for events in the REB EQ Dataset. One to four plots are shown from each region. These are also shown on the GTDB Web Site.

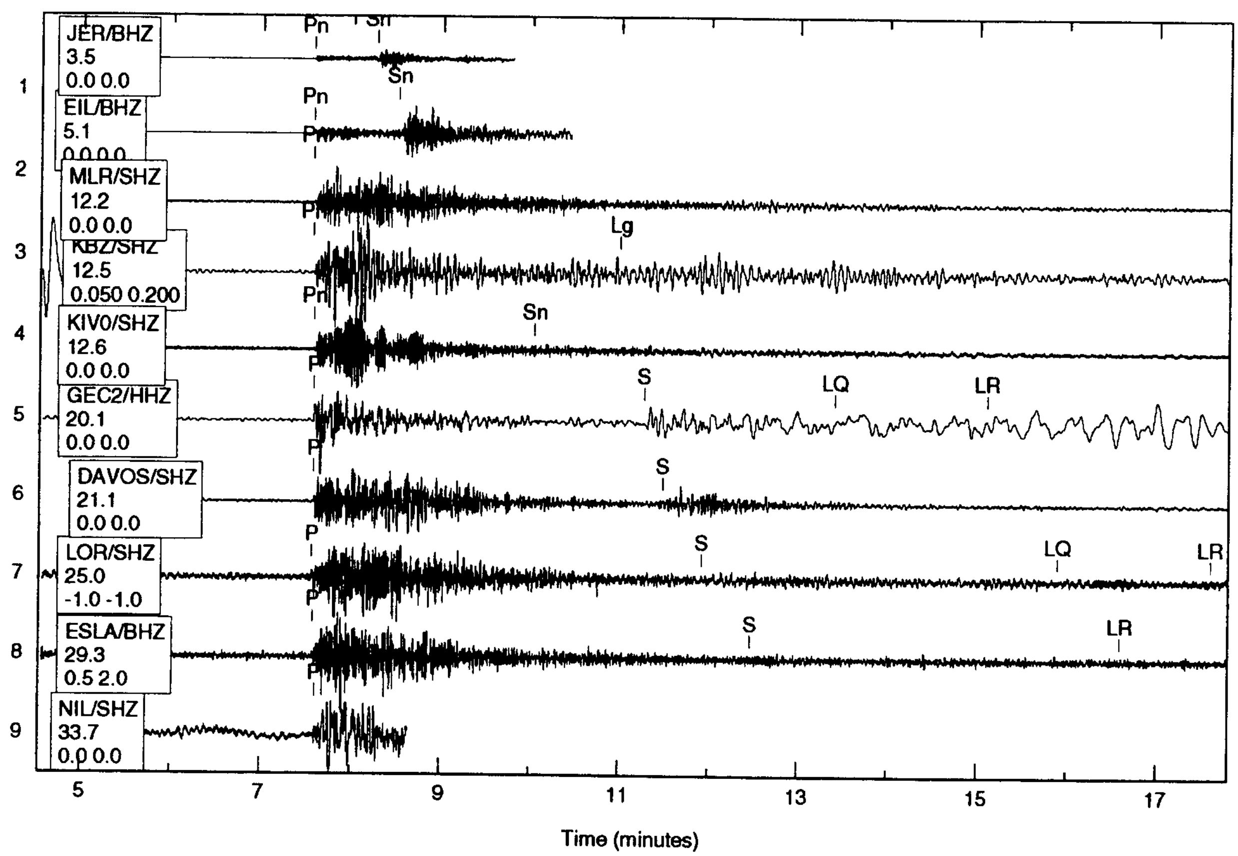
Time scales, which vary from plot-to-plot, are explained below each plot. Traces are usually aligned on the theoretical first arrival except where noted in the caption. Traces are usually shown after filtering with causal bandpass filters. Low and high corners of these filters are listed in the captions, or in the tags on the waveforms. Independent vertical scaling was applied to the traces.



Time scale: five units = one minute.

Figure 77: Event 6028 from the Cyprus region. Three-component broadband channels from JER and EIL show strong Pn and Sn crustal phases. Traces are aligned on Pn. Tag contents list station/channel and distance (degrees). All traces are unfiltered.

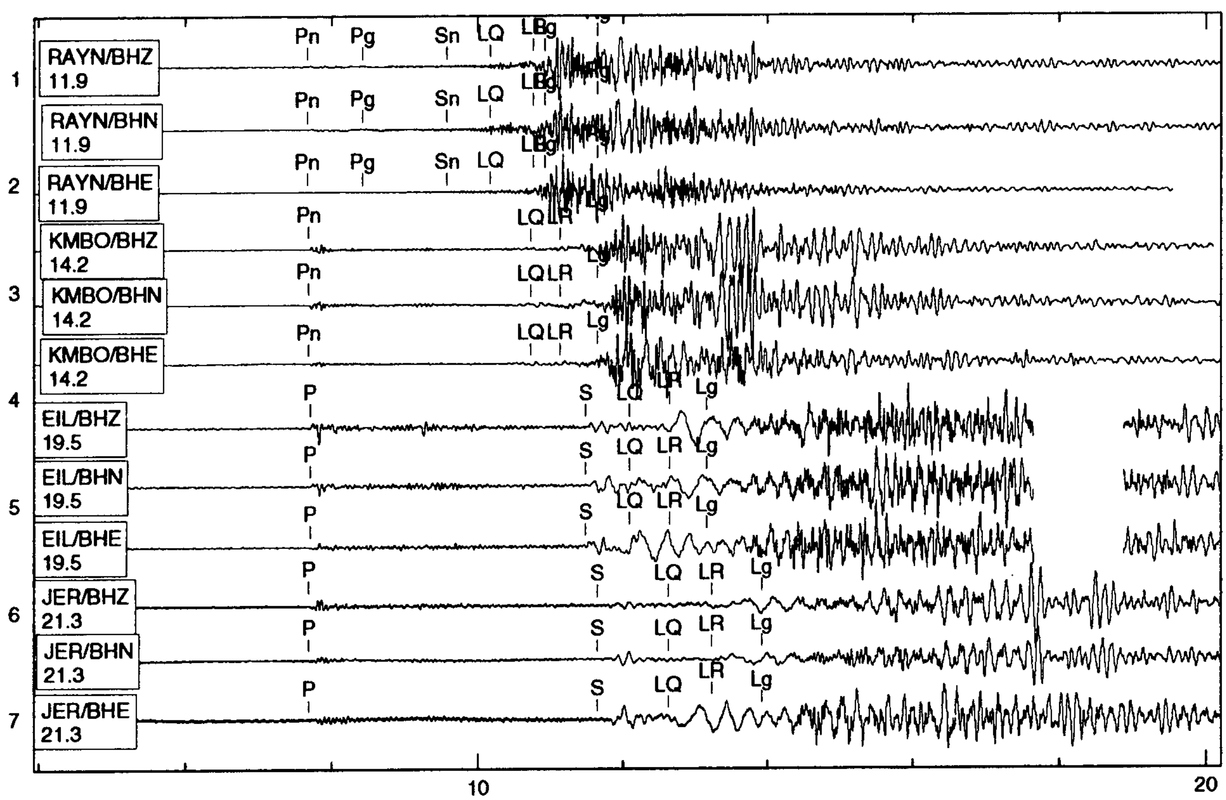
Cyprus ev6028 (mb 4.93)



Time scale: one unit = one minute.

Figure 78: Event 6028 from the Cyprus region. Recordings of vertical channels from 10 stations are shown. Traces are aligned on primary Pn or P. Tag contents list station/channel, distance (degrees), and filter (low, high). KBZ is filtered at 0.05-0.2 Hz and ESLA at 0.5-2.0 Hz. All other channels are unfiltered.

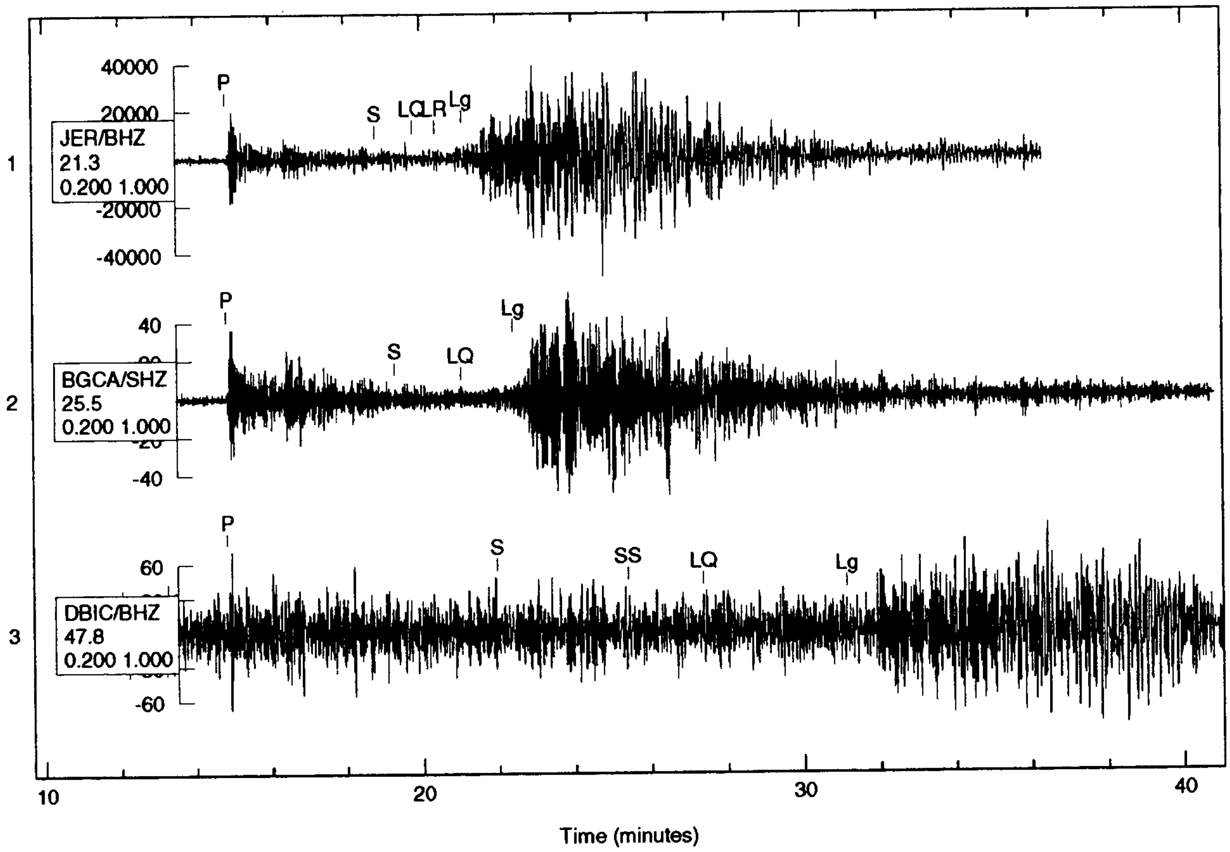
Ethiopia ev7005 (mb 4.48)



Time scale: one unit = two minutes.

Figure 79: Event 7005 from the Ethiopia cluster. Three-component broadband channels shown from regional and near teleseismic stations RAYN, KMBO, EIL, and JER. Traces are aligned on primary arrivals Pn or P. Tag contents list station/channel and distance (degrees). All traces are unfiltered.

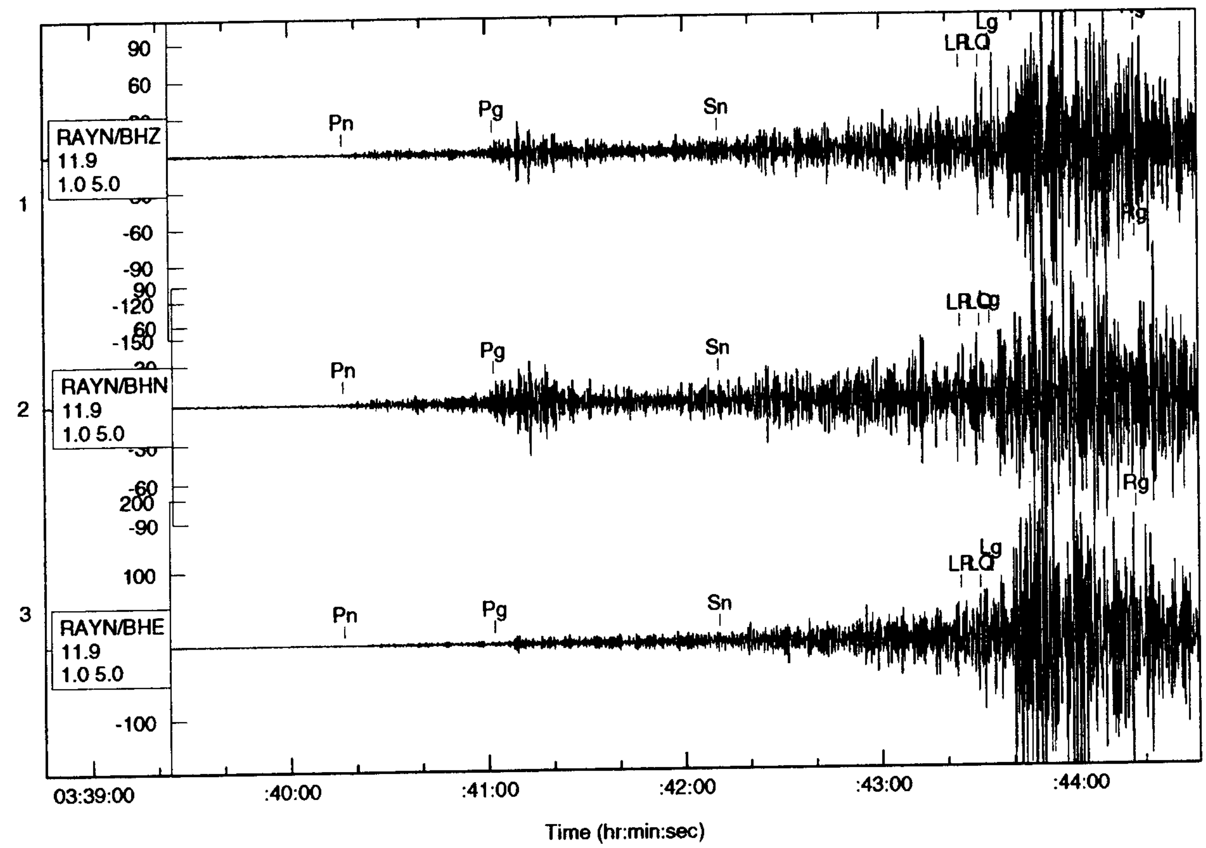
Ethiopia ev7005 (mb 4.48) Teleseismic Lg



Time scale: one unit = two minutes.

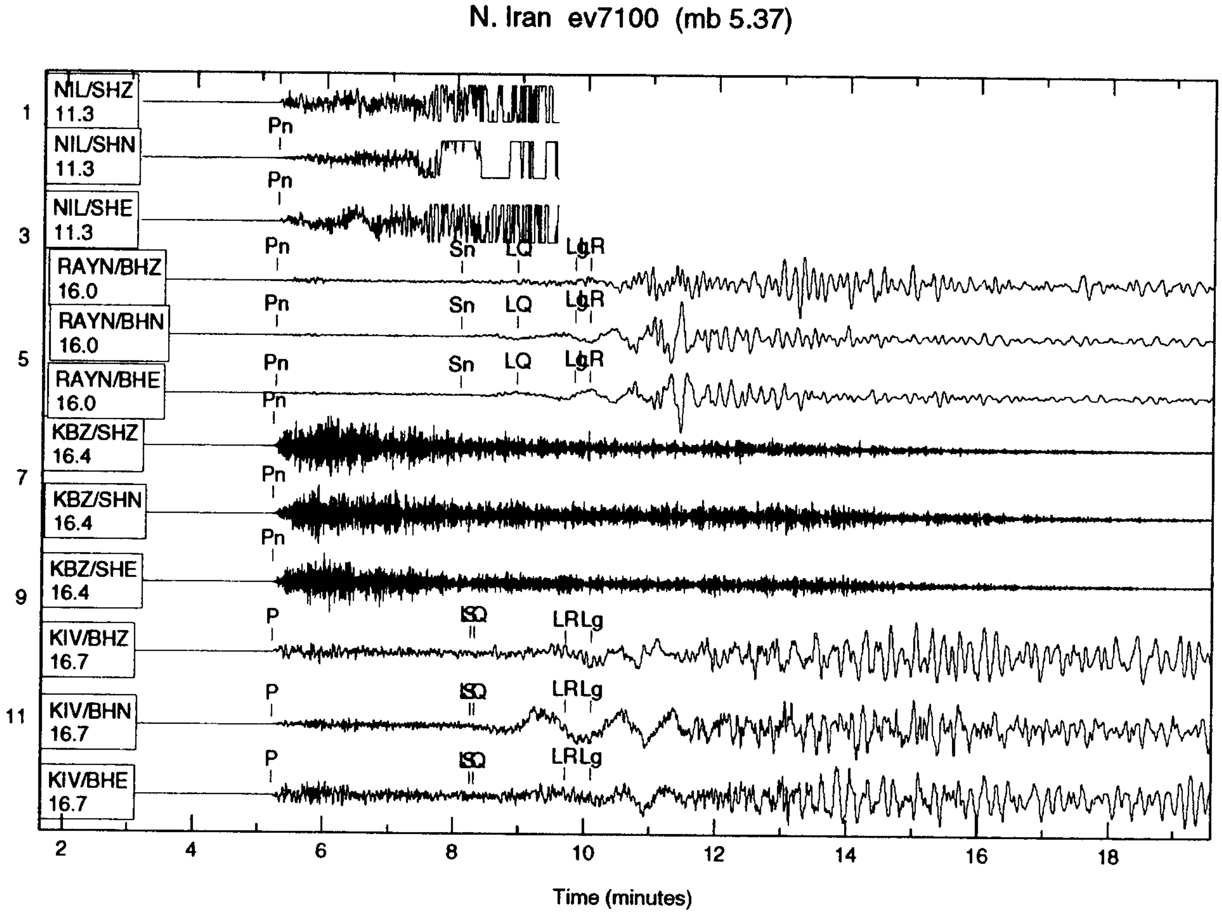
Figure 80: Event 7005 from the Ethiopia cluster. Vertical channels shown for teleseismic stations JER, BGCA, and DBIC aligned on P arrival. Tag contents list station/channel, distance and filter (low, high). All traces are filtered at 0.2-1.0 Hz. Note well recorded Lg's at teleseismic stations out to 48 degrees distance (DBIC). Typical Lg period of 2-3 seconds can be observed for these stations when zoomed in. Phase arrivals S, SS, and LQ were picked on horizontal channels, and LR was observed with a longer period bandpass filter.

Ethiopia ev7002 (mb 3.99)



Time scale: three units = one minute.

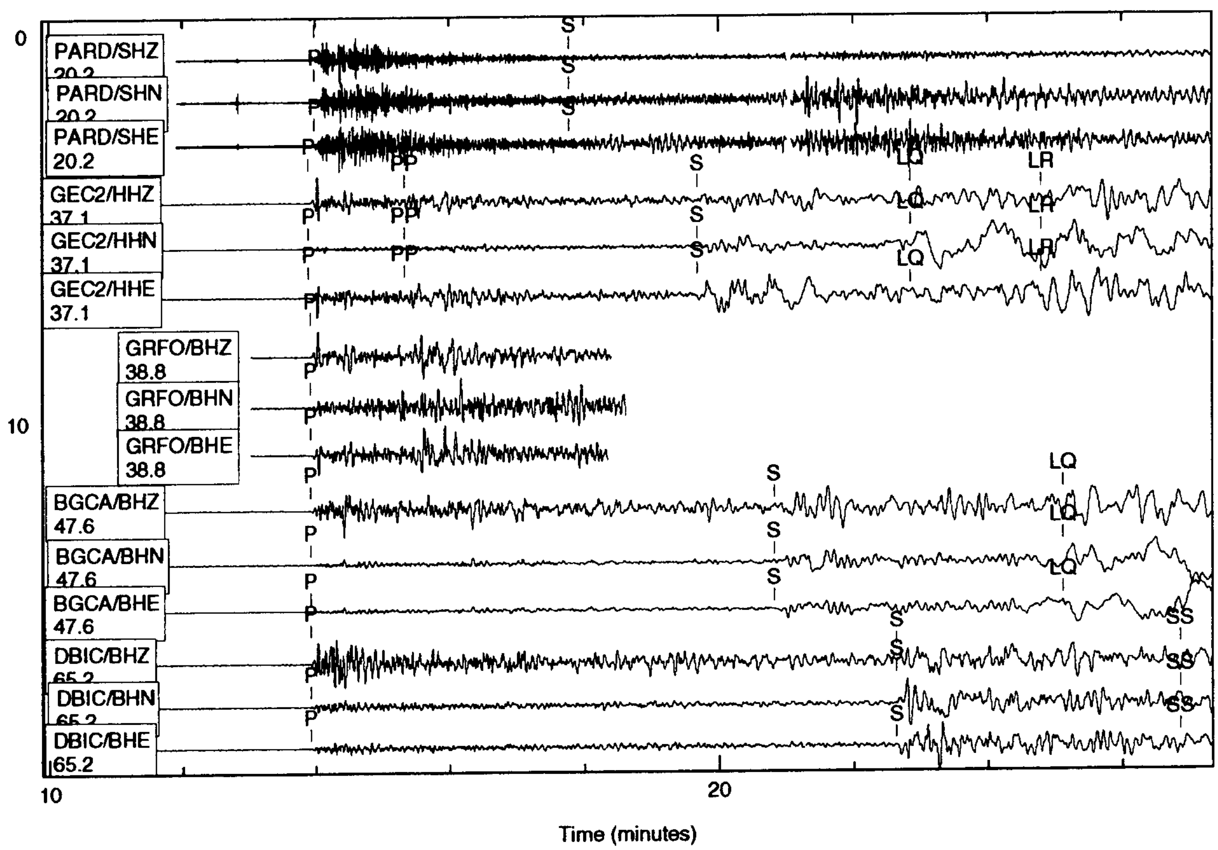
Figure 81: Event 7002 from the Ethiopia cluster. Three-component broadband recording from station RAYN filtered at 1-5 Hz. Tag contents list station/channel, distance (degrees), and filter (low, high). Note strong Pg and Lg crustal phases at nearly 12 degrees distance.



Time scale: one unit = one minute.

Figure 82: Event 7100 from N. Iran region. Regional three-component stations NIL, RAYN, KBZ, and KIV shown for main event with traces aligned on Pn or P. Tag contents list station/channel and distance (degrees). All traces are unfiltered. NIL Sn and Lg phases are clipped.

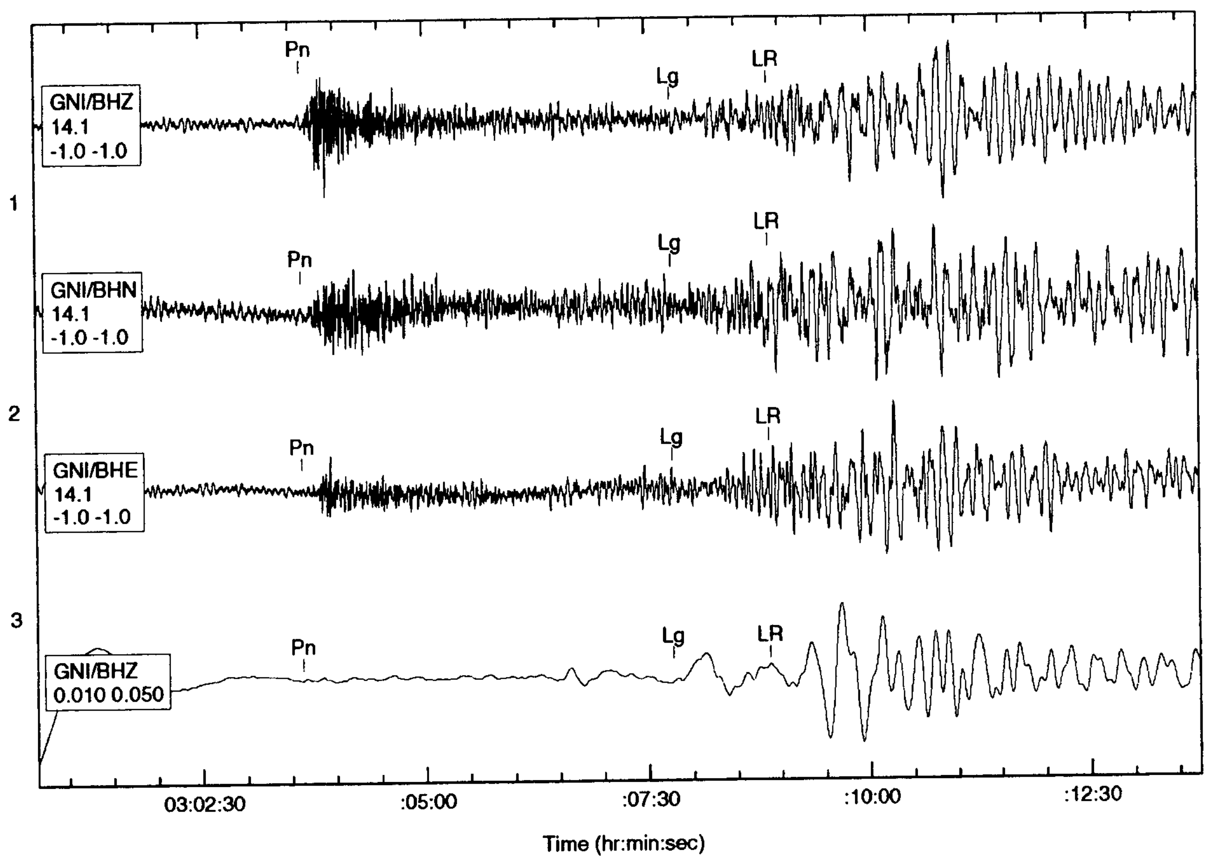
N. Iran ev7100 (mb 5.37)



Time scale: one unit = two minutes.

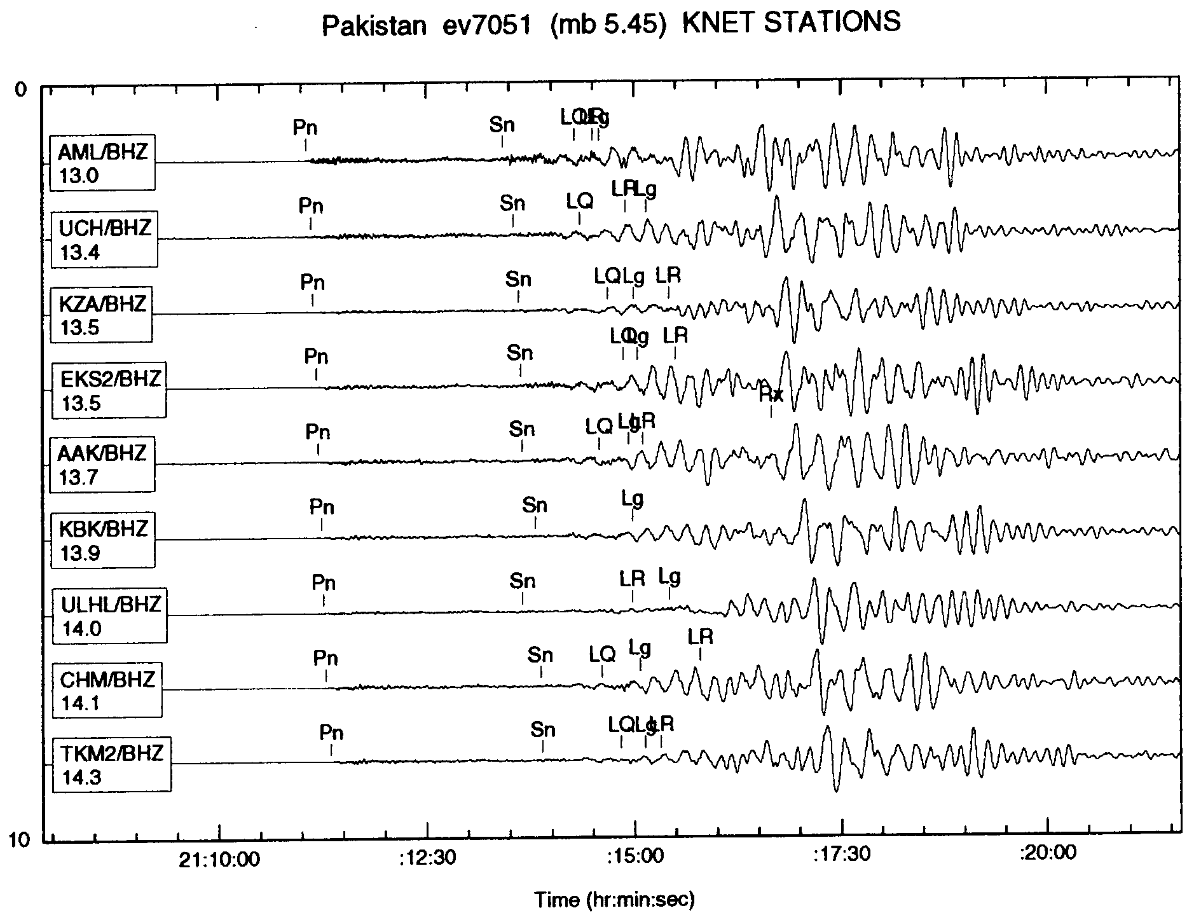
Figure 83: Event 7100 from N. Iran region. Teleseismic three-component stations PARD, GEC2, GRFO, BGCA, and DBIC shown for main event with traces aligned on P. Tag contents list station/channel and distance (degrees). All traces are unfiltered.

N. Iran ev7125 (mb 4.51) GNI



Time scale: two units = one minute.

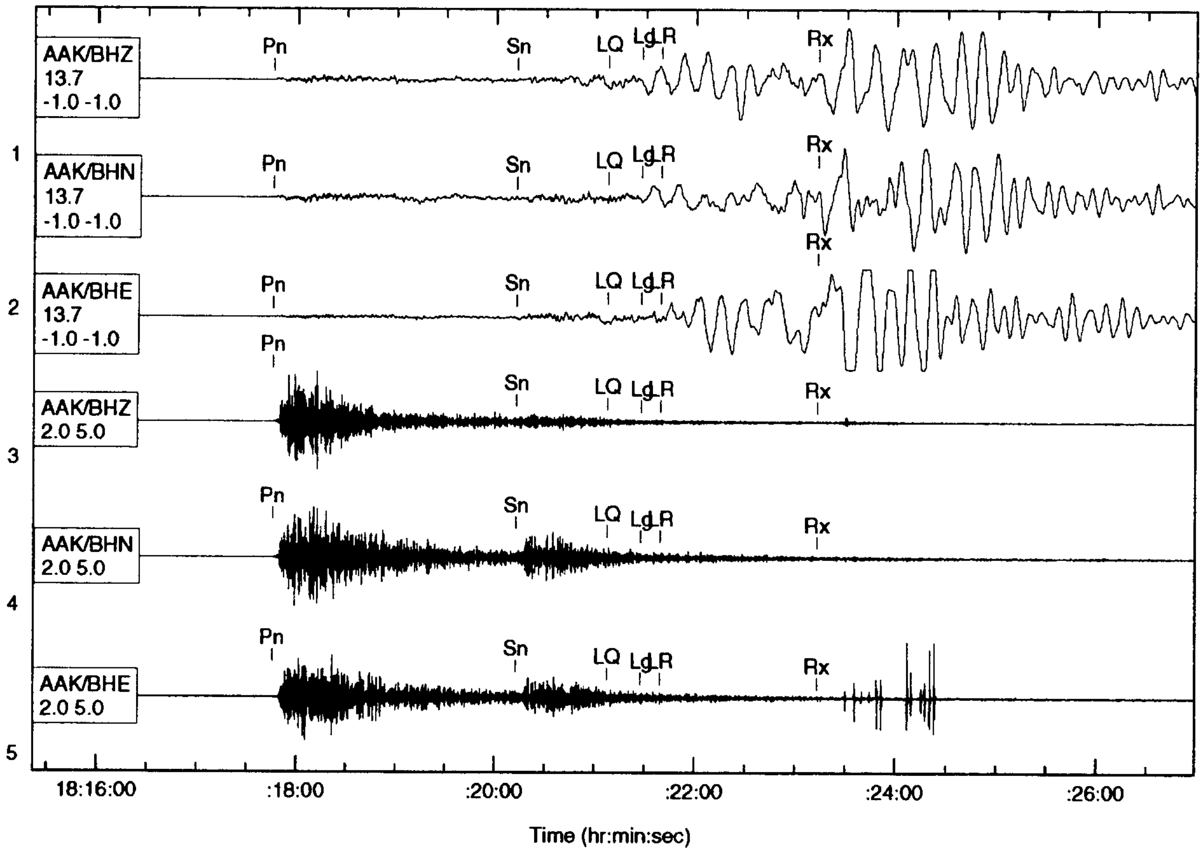
Figure 84: Event 7125 from the N. Iran region. Three-component channels from station GNI are shown. Top three traces are unfiltered, and bottom trace (BHZ) is filtered at 0.01-0.05 Hz to enhance LR phase. Weak Sn phase was not picked. Station-to-event azimuth (backazimuth) is 114 degrees. Tag contents list station/channel, distance (top traces only), and filter (low, high). Station GNI was unavailable for other events in this dataset.



Time scale: two units = one minute.

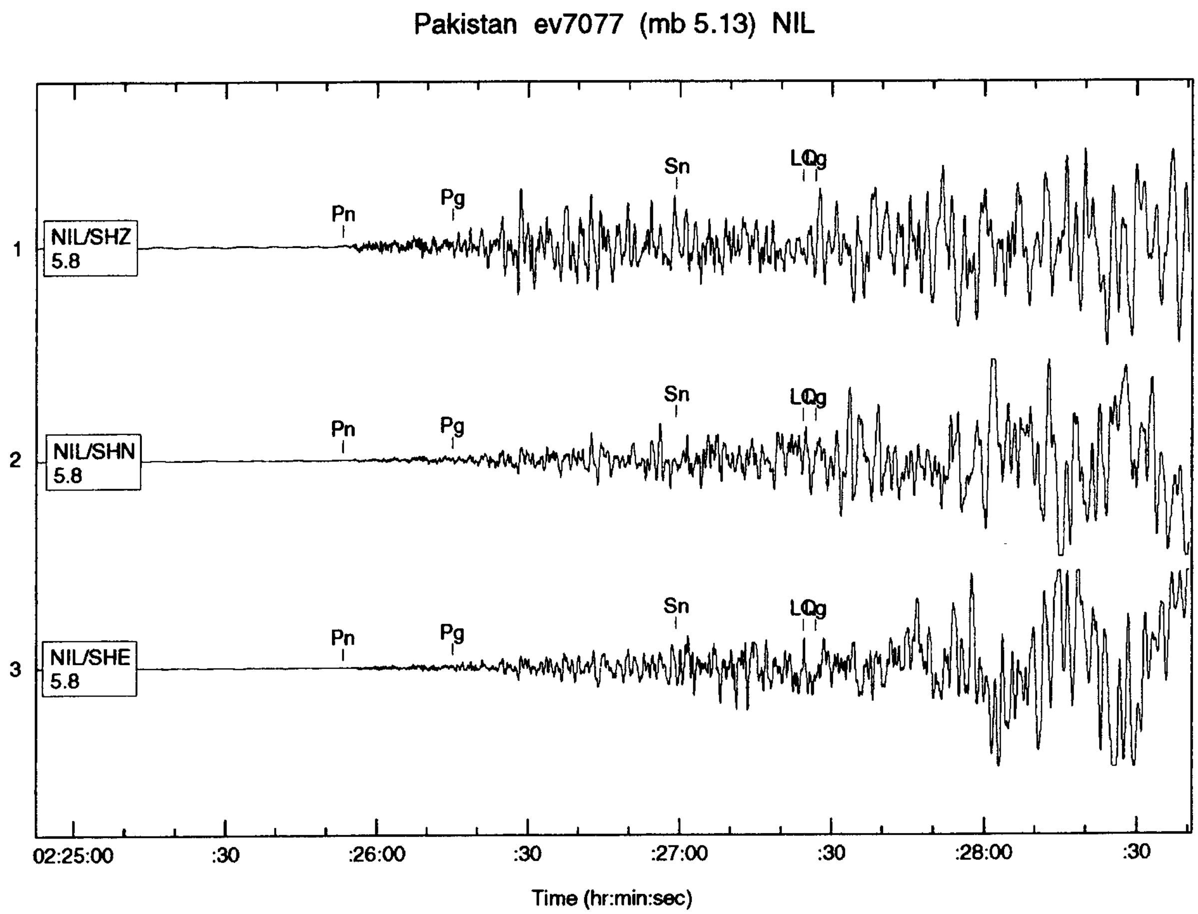
Figure 85: Event 7051 from the Pakistan region. Vertical channels from nine KNET stations are shown. Traces are unfiltered and unaligned. Tag contents list station/channel and distance (degrees).

Pakistan ev7051 (mb 5.45) AAK



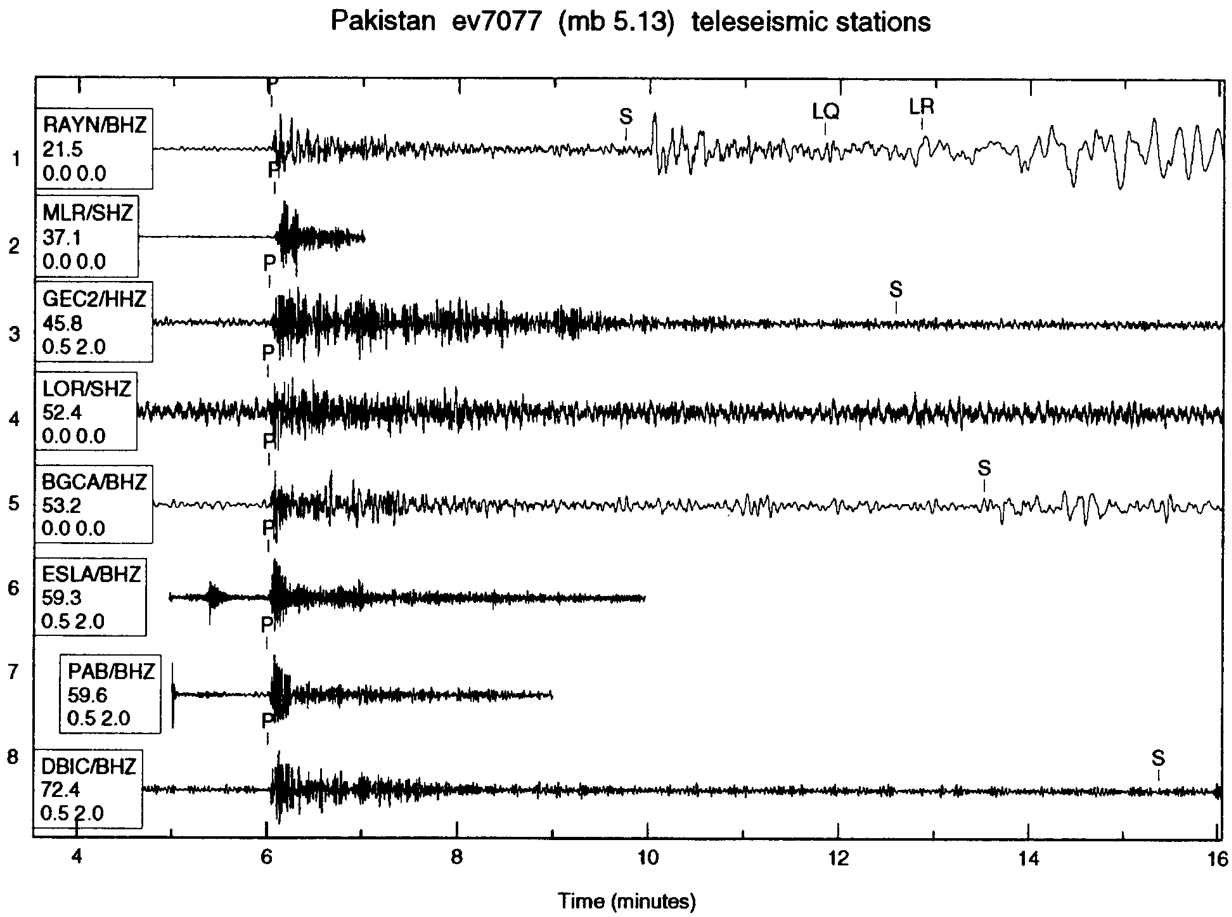
Time scale: two units = one minute.

Figure 86: Event 7051 from the Pakistan region. Three-component channels from station AAK are displayed. The top three traces are unfiltered and the bottom three traces are filtered at 2.0-5.0 Hz. Tag contents list station/channel, distance (top three traces only), and filter (low, high). Spiking on the filtered BHE channel after Rx (unknown Rayleigh) arrival is an artifact of filtering clipped data. Surface waves LQ and LR were timed using a low-frequency bandpass filter.



Time scale: six units = one minute.

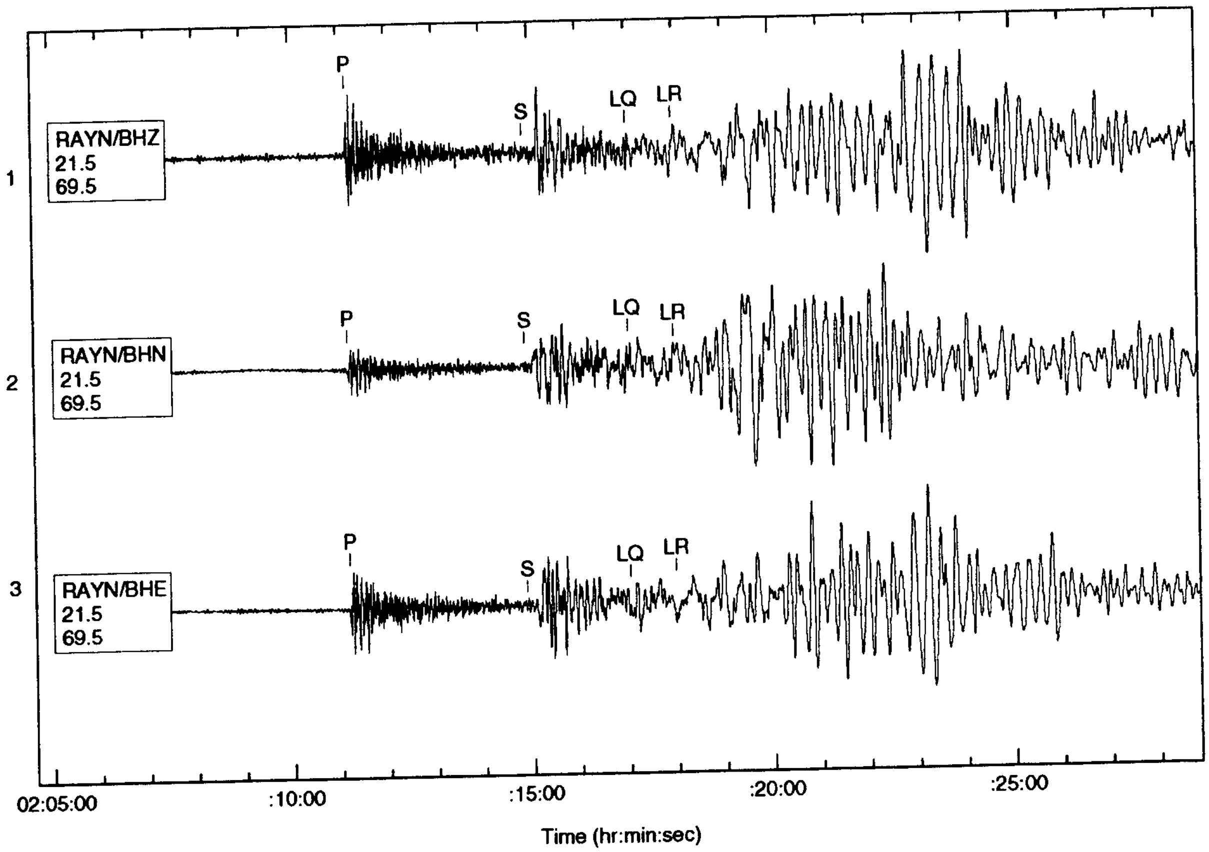
Figure 87: Event 7077 from the Pakistan region. Unfiltered short-period three-component channels from NIL (Nilore, Pakistan) are shown. Station-to-event azimuth (backazimuth) is 223 degrees. Station-to-event distance is 5.8 degrees.



Time scale: one unit = one minute.

Figure 88: Event 7077 from the Pakistan region. Vertical channels from teleseismic stations are displayed. Traces are aligned on expected P time. Traces are either unfiltered or filtered at 0.5-2.0 Hz. Tag contents list station/channel, distance (degrees), and filter (low, high).

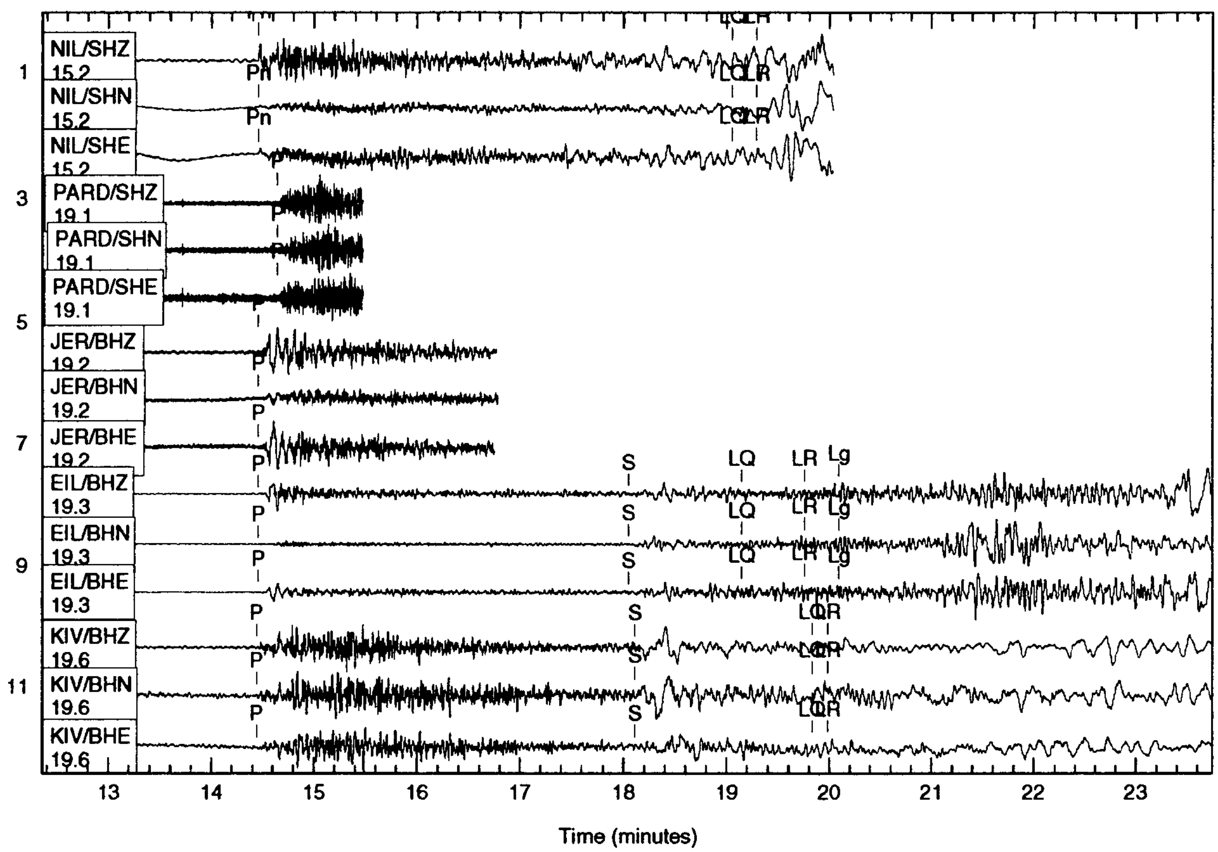
Pakistan ev7077 (mb 5.13) RAYN



Time scale: one unit = one minute.

Figure 89: Event 7077 from the Pakistan region. Unfiltered three-component broadband channels at RAYN are displayed. Tag contents list station/channel, distance (degrees), and station-to-event azimuth (degrees).

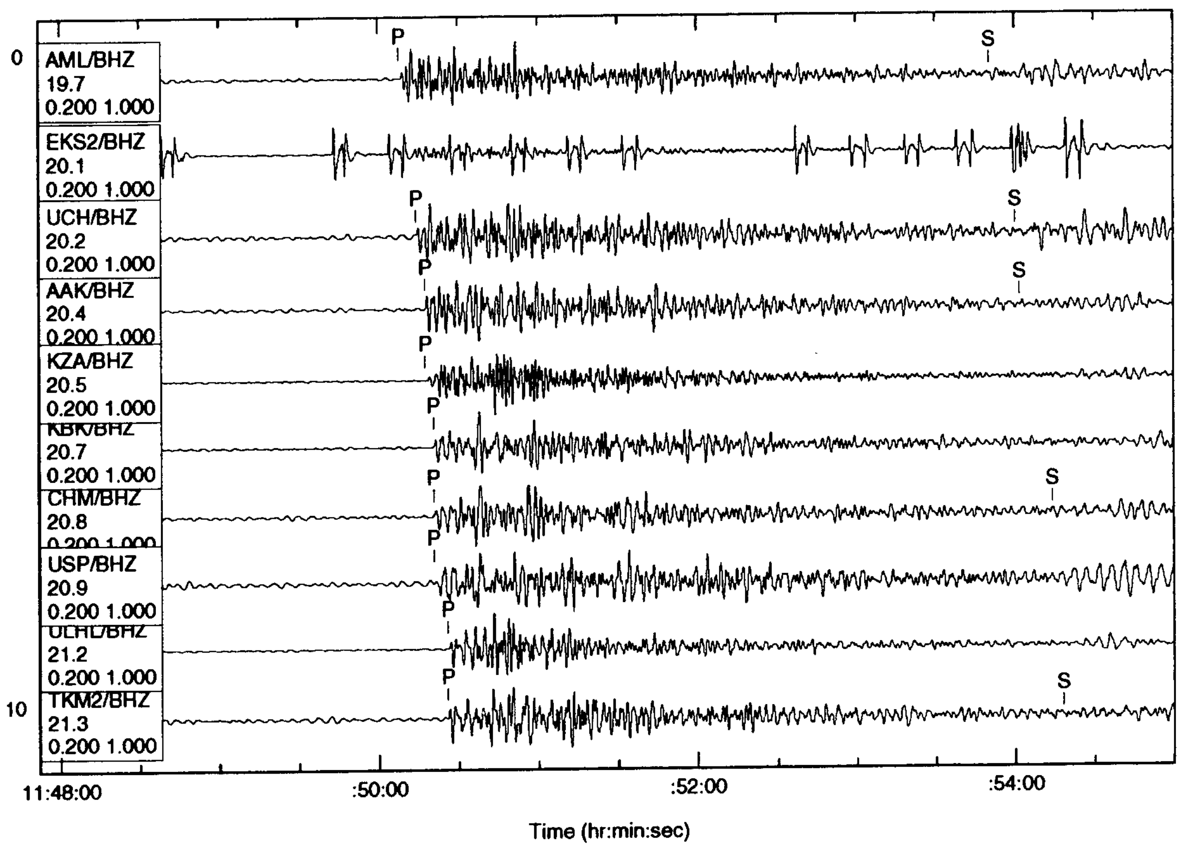
Hormuz ev7150 (mb 4.8)



Time scale: five units = one minute.

Figure 90: Event 7150 from the Hormuz region. Regional three-component stations NIL, PARD, JER, EIL, and KIV shown for main event with traces aligned on Pn or P. Tag contents list station/channel and distance (degrees). All traces are unfiltered. Surface waves LQ and LR were picked using a low-frequency filter. Station PARD has a possible late timing error.

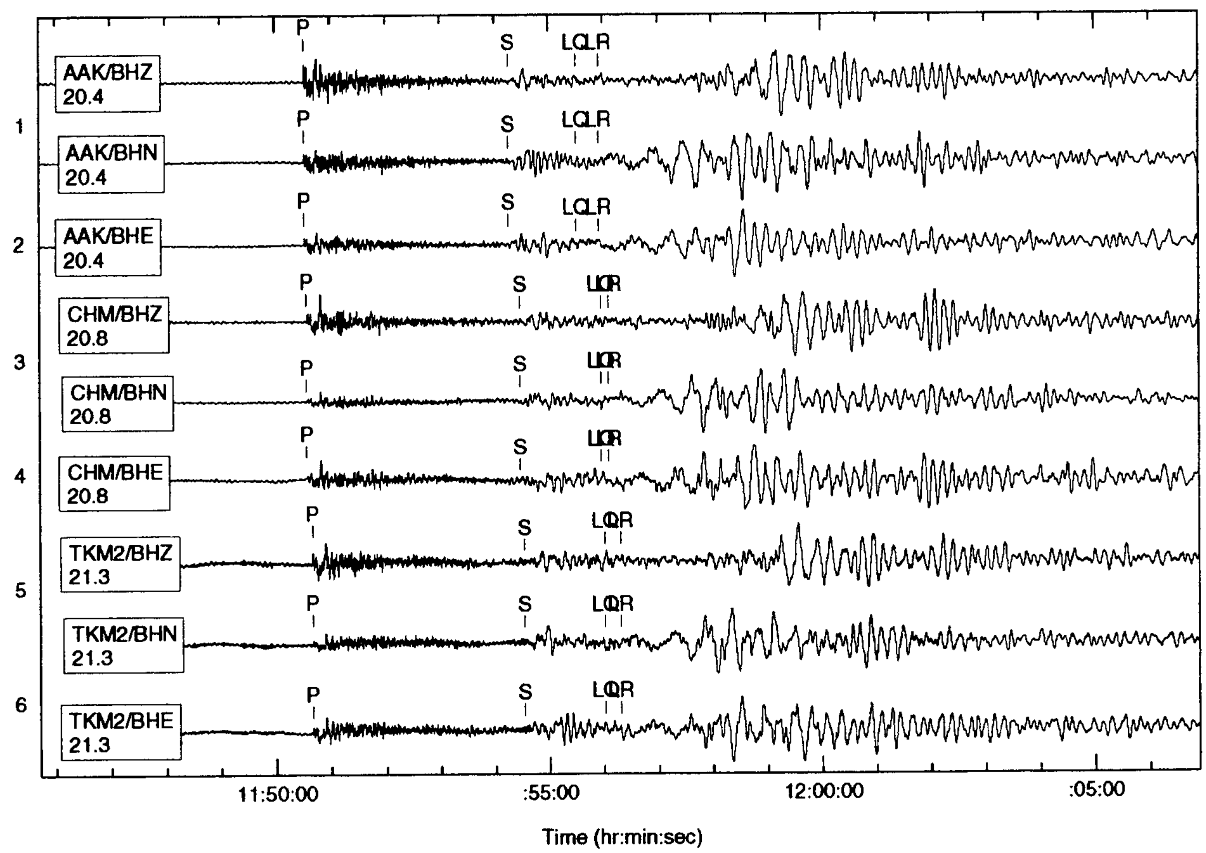
Hormuz ev7150 (mb 4.8) KNET STATIONS



Time scale: two units = one minute.

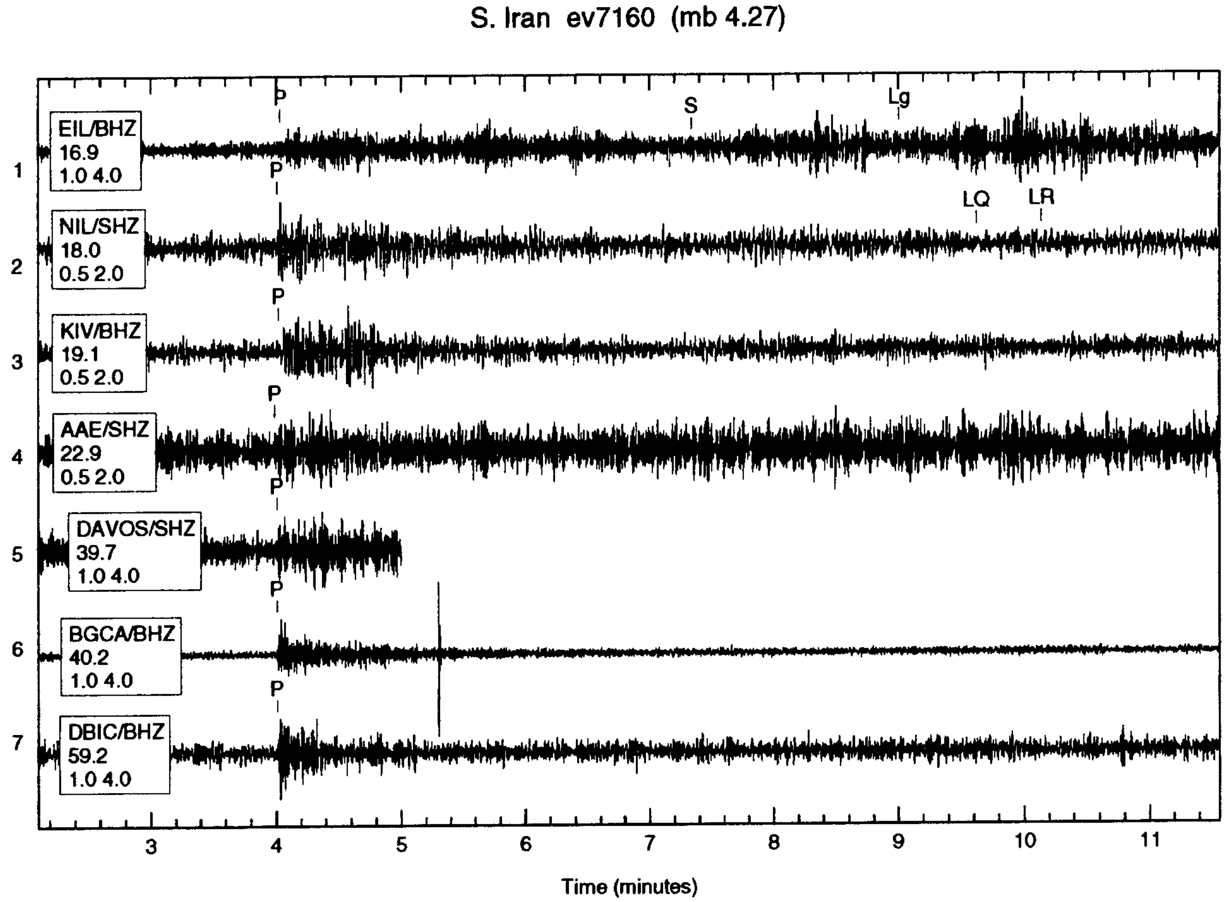
Figure 91: Event 7150 from the Hormuz region. Vertical channels from 10 KNET stations are displayed unaligned in order of increasing distance and filtered at 0.2-1.0 Hz. Spikes or glitches obscure phase arrivals on some traces. Tag contents list station/channel, distance (degrees), and filter (low, high).

Hormuz ev7150 (mb 4.79) KNET



Time scale: one unit = one minute.

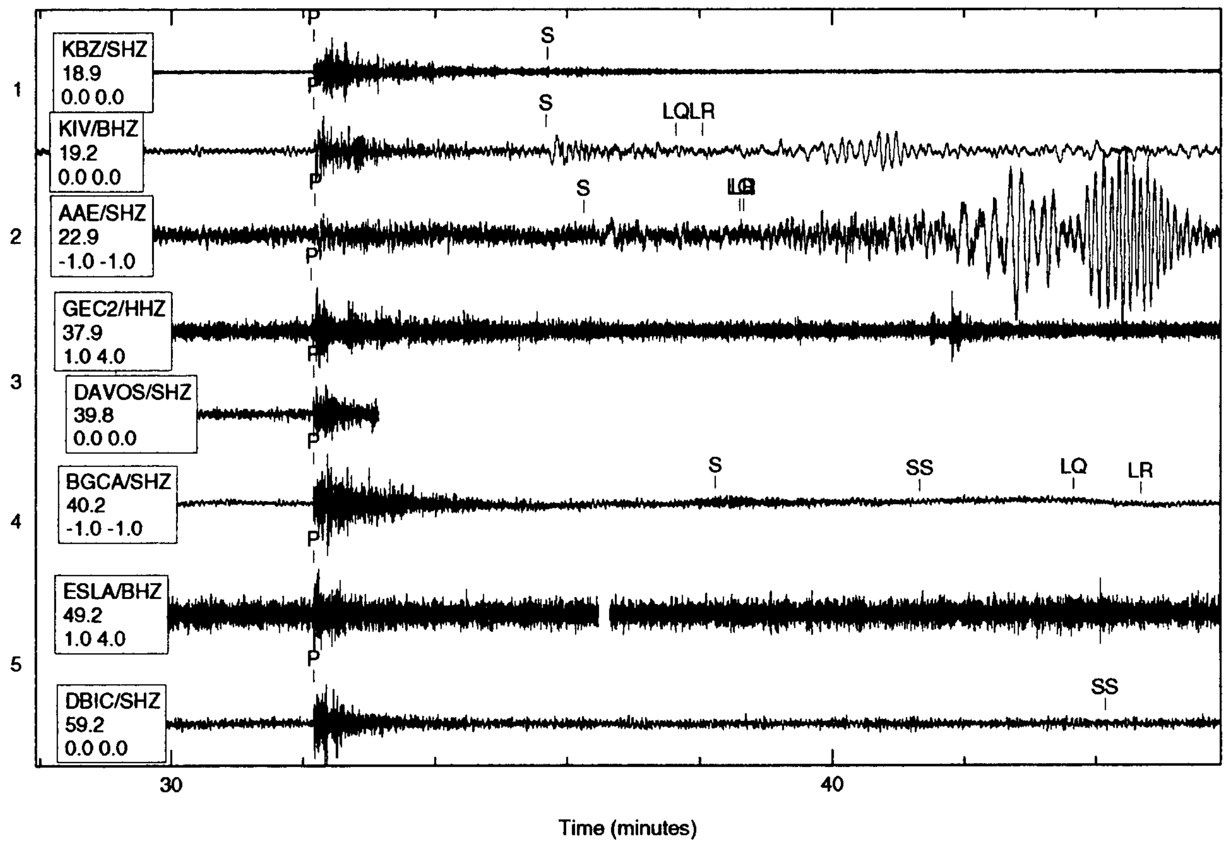
Figure 92: Event 7150 from the Hormuz region. Three-component broadband channels from KNET stations AAK, CHM, and TKM2 are shown. Traces are unaligned and unfiltered. Tag contents list station/channel and distance (degrees). Surface waves LQ and LR were picked using a low-frequency filter.



Time scale: five units = one minute.

Figure 93: Event 7160 from the S. Iran region. Vertical channels from stations EIL, NIL, KIV, AAE, DAVOS, BGCA, and DBIC are displayed with traces aligned on P. Tag contents list station/channel, distance (degrees), and filter (low, high).

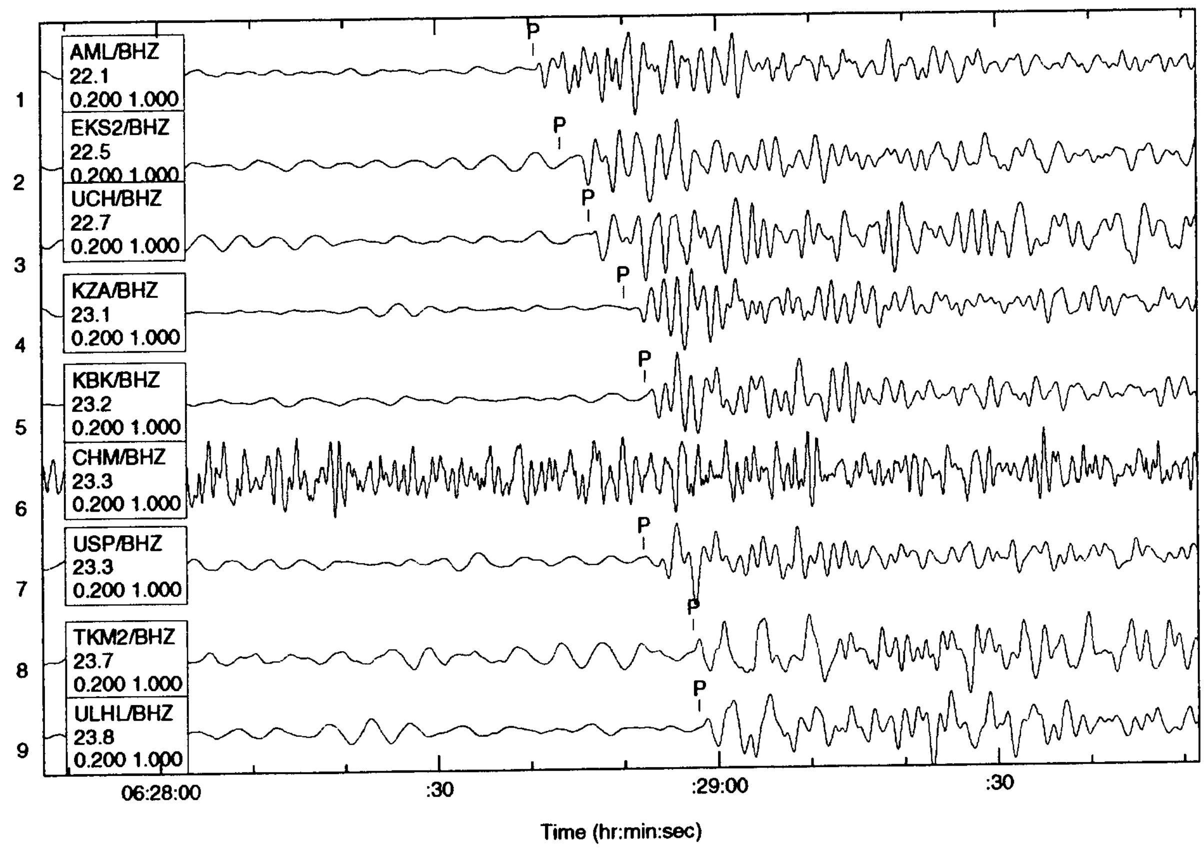
S. Iran ev7162 (mb 4.53)



Time scale: one unit = two minutes.

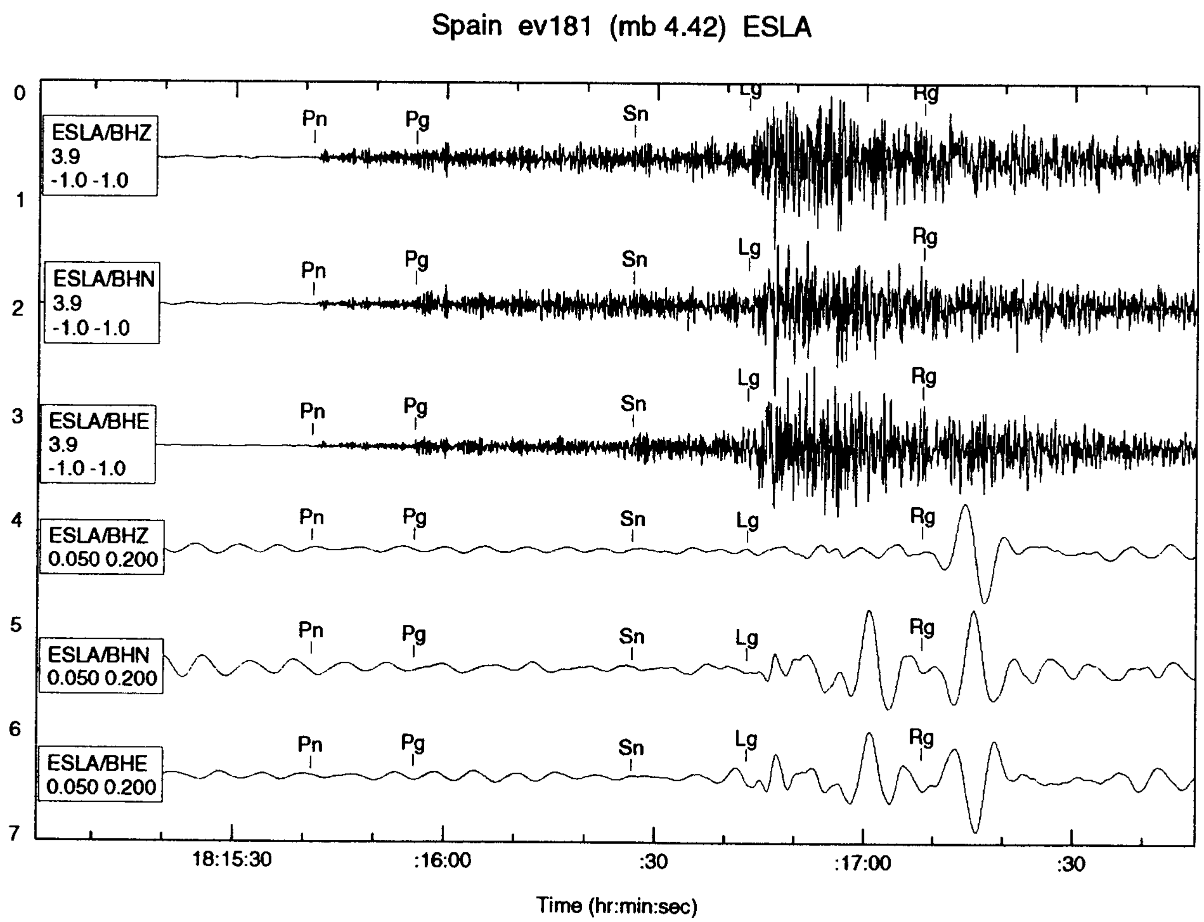
Figure 94: Event 7162 from the S. Iran region. Vertical channels aligned on P are shown from stations KBZ, KIV, AAE, GEC2, DAVOS, BGCA, ESLA, and DBIC. Tag contents list station/channel, distance (degrees), and filter (low, high). All traces except GEC2 and ESLA are unfiltered.

S. Iran ev7162 (mb 4.53) KNET STATIONS



Time scale: six units = one minute.

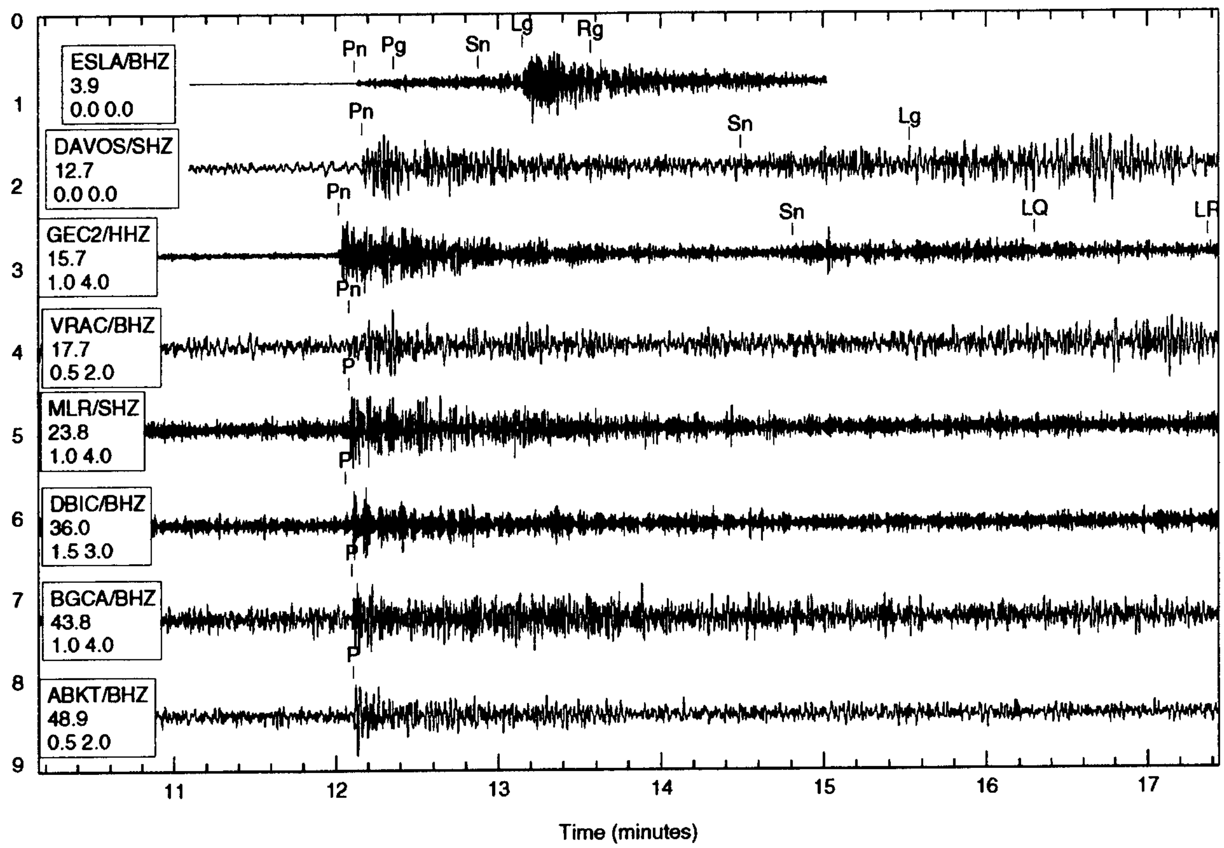
Figure 95: Event 7162 from the S. Iran region. Vertical broadband channels from nine KNET stations are displayed. Traces are unaligned and filtered at 0.2-1.0 Hz. Tag contents list station/channel, distance (degrees), and filter (low, high). Station CHM shows poor signal to noise ratio on channels BHZ and BHN, but a signal was observed on channel BHE.



Time scale: six units = one minute.

Figure 96: Event 181 from the Spain region. Recordings at ESLA (Sonseca, Spain) show crustal phases. Top three traces are unfiltered three-component channels. Bottom three traces are filtered at 0.05-0.2 Hz to enhance Rg phase. Tag contents list station/channel, distance (top only), and filter (low, high). The station-to-event azimuth (backazimuth) is 323 degrees.

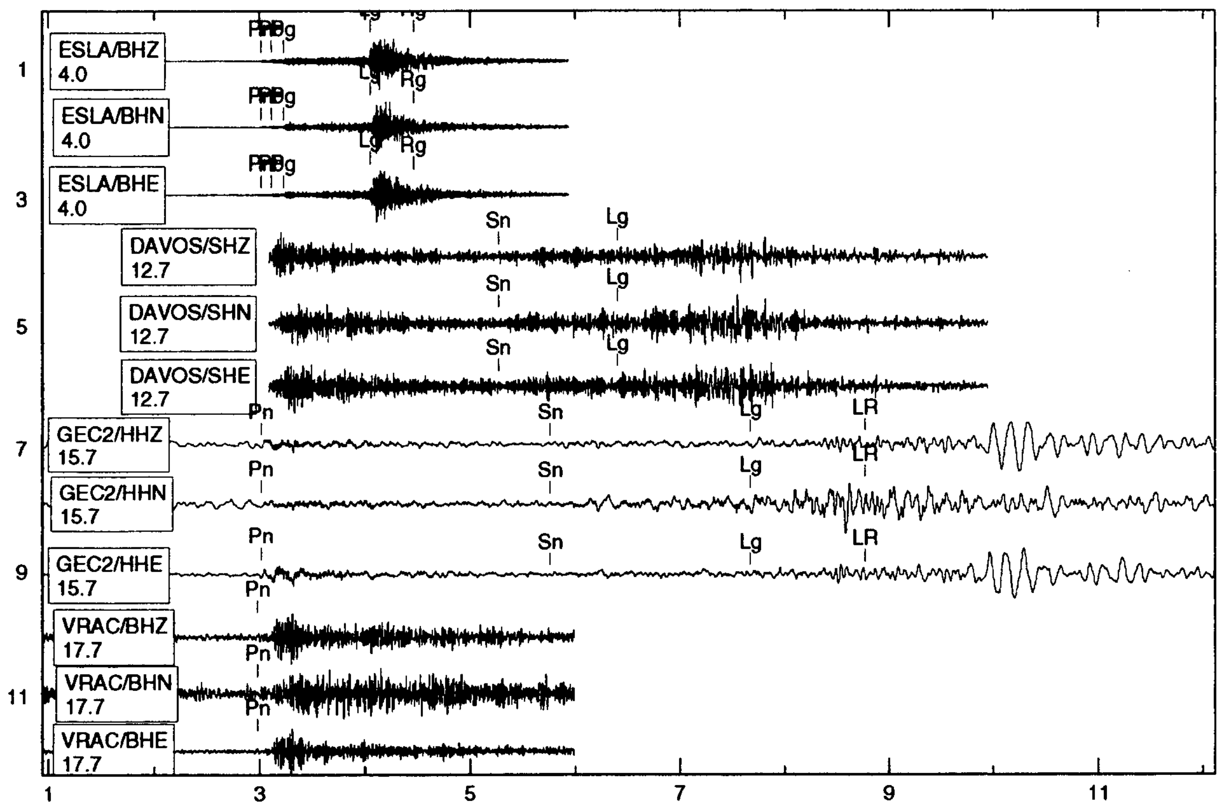
Spain ev181 (mb 4.42)



Time scale: five units = one minute.

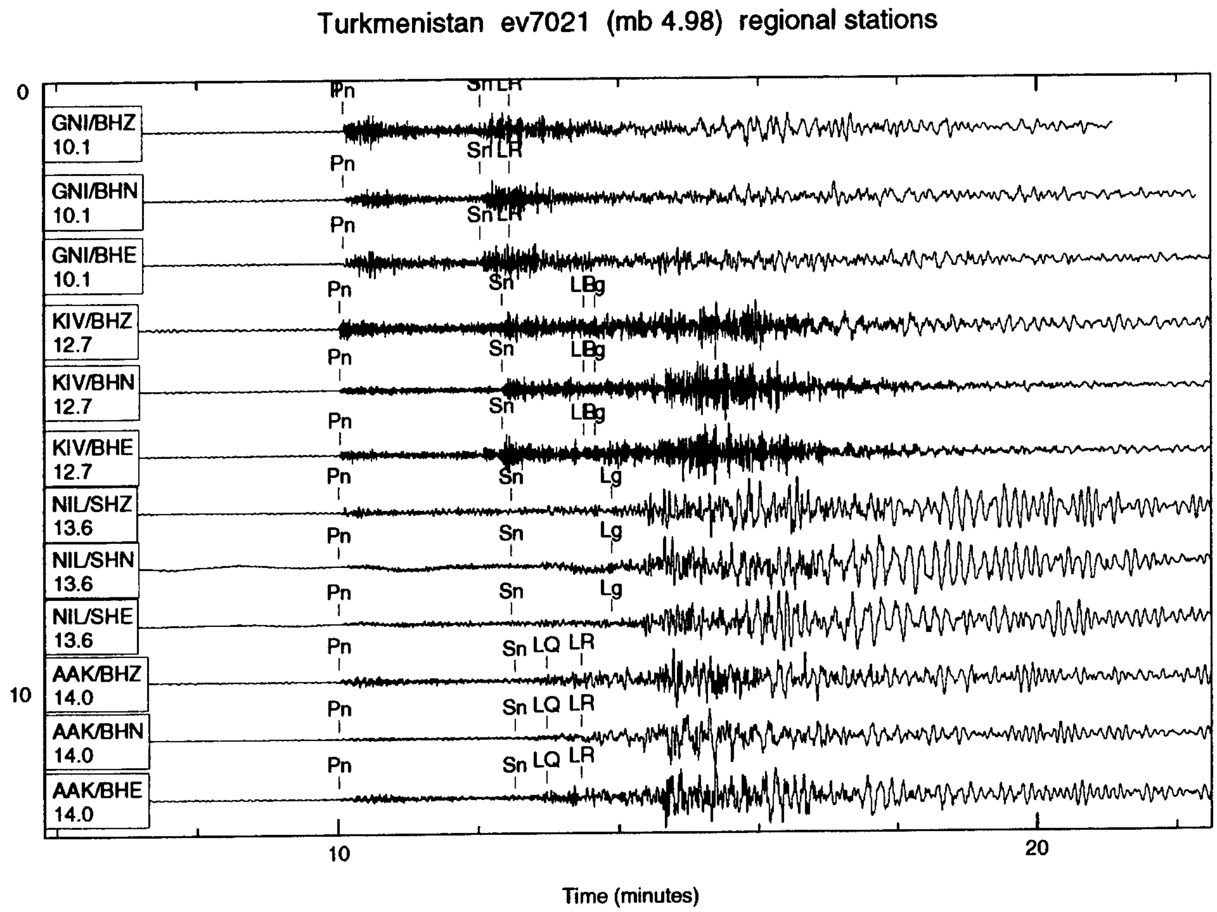
Figure 97: Event 181 from the Spain region. Vertical channels from regional and teleseismic stations are displayed. Traces are aligned on primary Pn or P. Traces are filtered at various passbands except ESLA and DAVOS which are unfiltered. Tag contents list station/channel, distance (degrees), and filter (low, high).

Spain ev177 (mb 4.50)



Time scale: one unit = one minute.

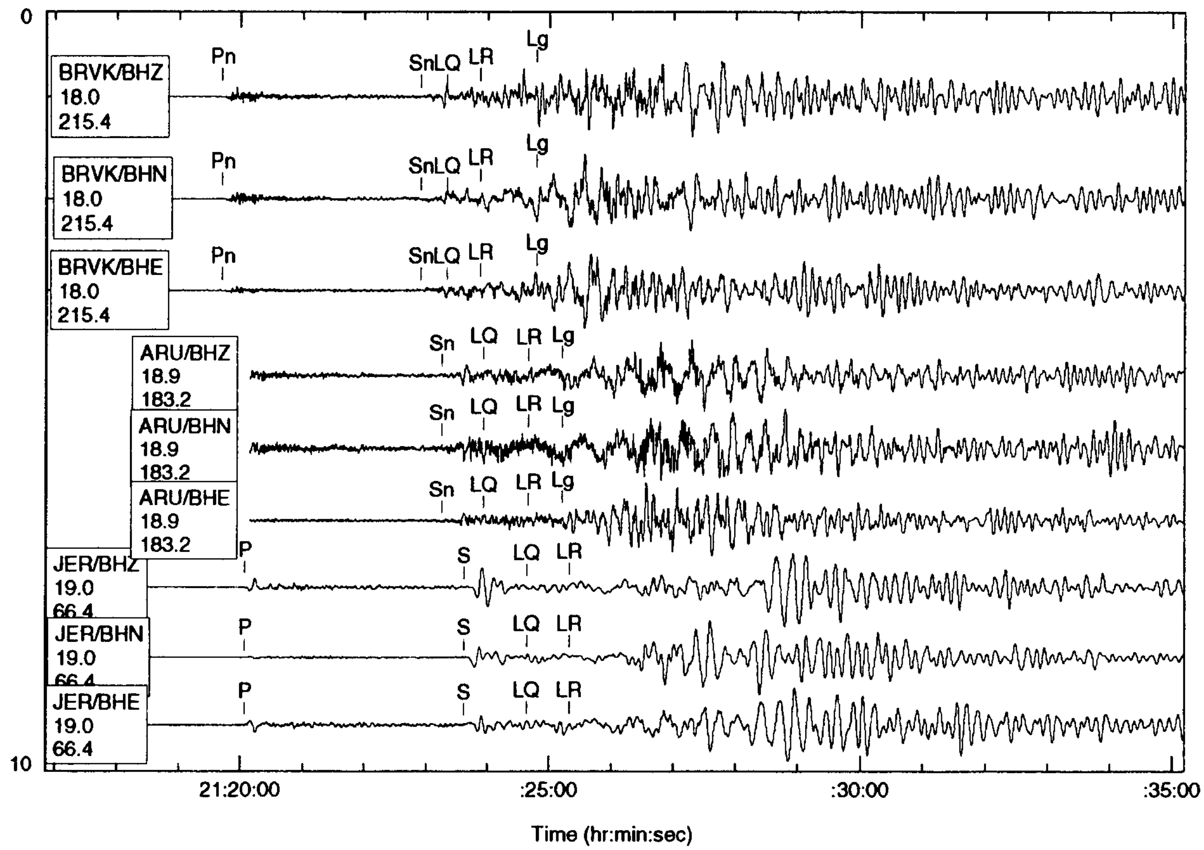
Figure 98: Event 177 from the Spain region. Three-component channels from regional stations ESLA, DAVOS, GEC2, and VRAC are shown. Traces are aligned on Pn and unfiltered except VRAC which is filtered at 0.5-2.0 Hz. Tag contents list station/channel and distance (degrees).



Time scale: one unit = two minutes.

Figure 99: Event 7021 from the Turkmenistan region. Three-component channels from four regional stations (GNI, KIV, NIL, AAK) are displayed. All traces are unfiltered and aligned on theoretical Pn. Tag contents list station/channel and distance (degrees). Surface waves LQ and LR were picked with a low-frequency bandpass filter.

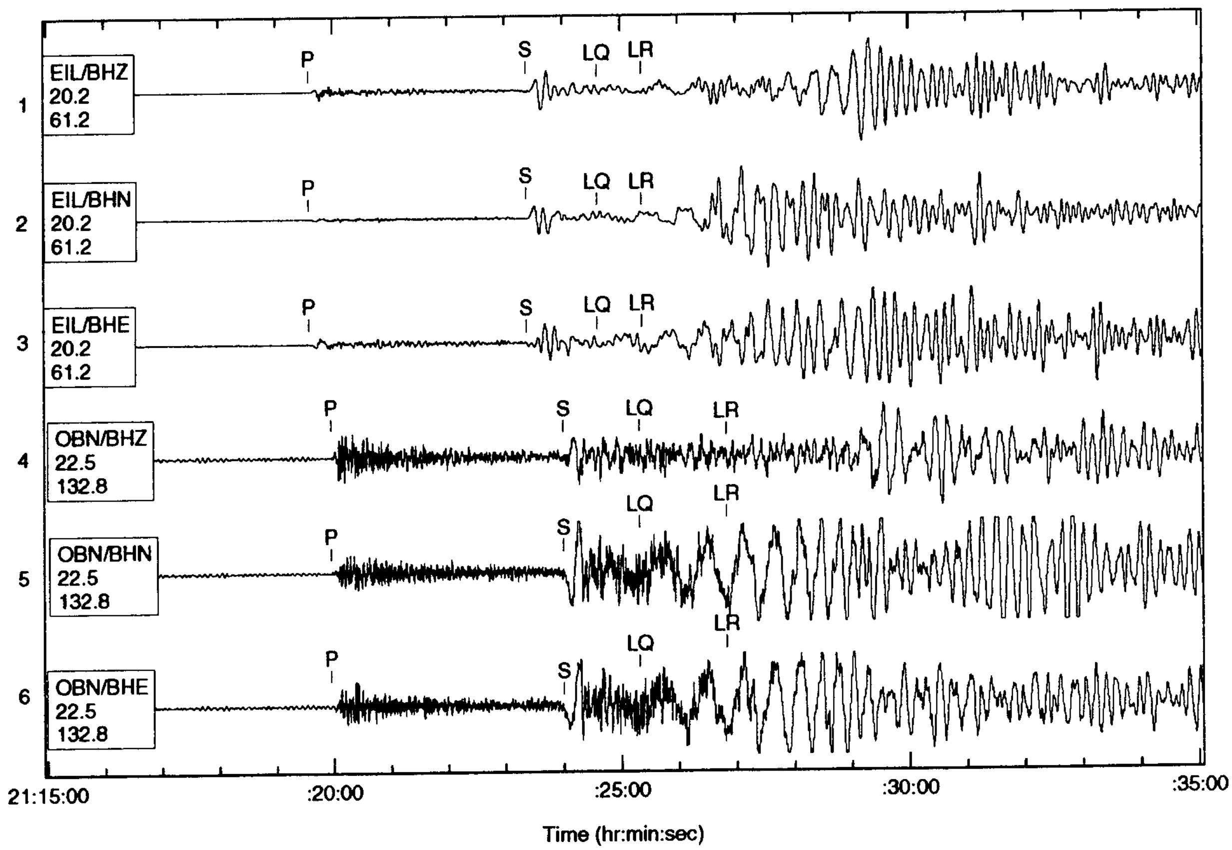
Turkmenistan ev7022 (mb 5.31) far regional stations



Time scale: one unit = one minute.

Figure 100: Event 7022 from the Turkmenistan region. Three-component channels from far-regional stations BRVK, ARU, and JER are displayed. Traces are unfiltered and unaligned. Tag contents list station/channel, distance (deg), and backazimuth (deg). The waveform segment for ARU begins after the first arrival.

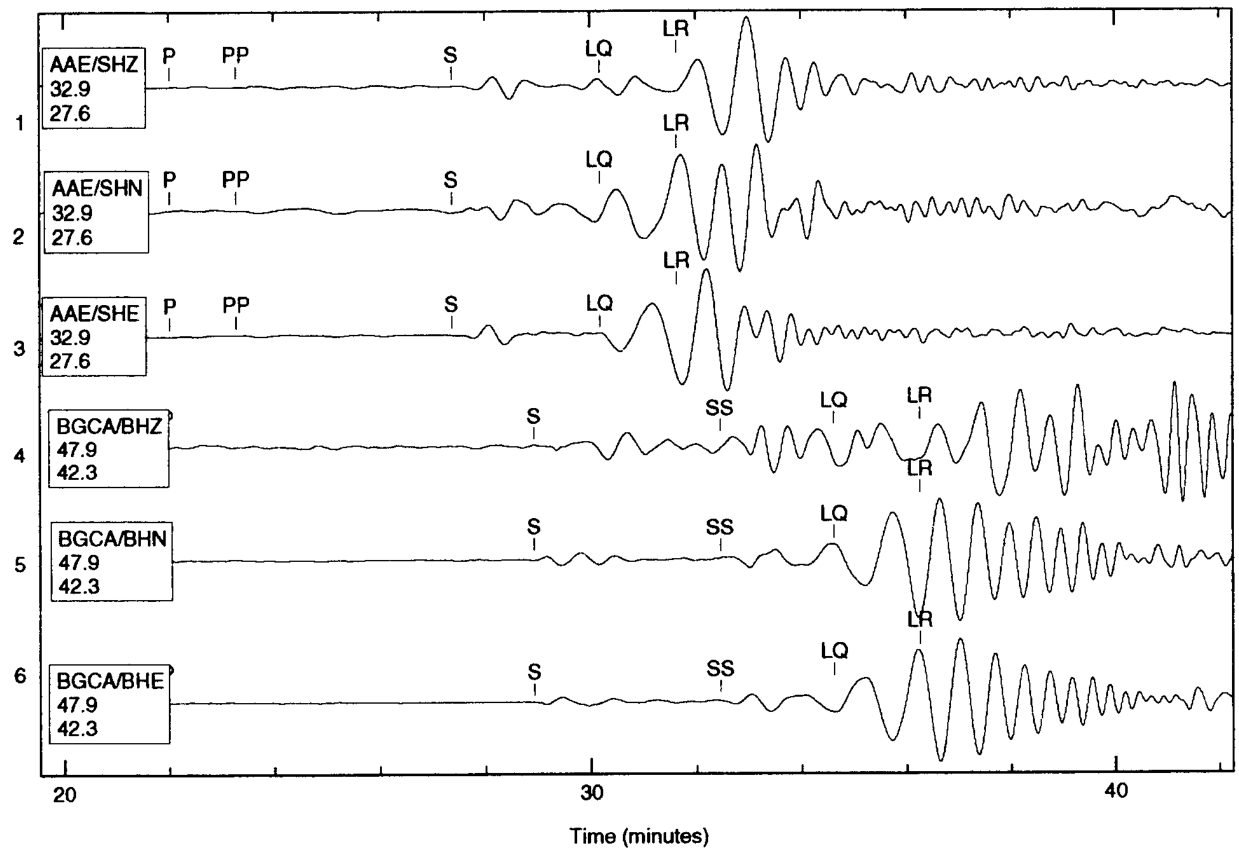
Turkmenistan ev7022 (mb 5.31) near teleseismic stations



Time scale: one unit = one minute.

Figure 101: Event 7022 from the Turkmenistan region. Three-component broadband channels from near-teleseismic stations EIL and OBN are shown. Tag contents list station/channel, distance (deg), and backazimuth (deg). Traces are unfiltered and unaligned.

Turkmenistan ev7022 (mb 5.31) , filtered 0.005-0.02 Hz



Time scale: one unit = two minutes.

Figure 102: Event 7022 from the Turkmenistan region. Three-component channels from teleseismic stations AAE and BGCA show prominent surface waves LQ and LR. Traces are aligned on theoretical P and filtered with low-frequency filter 0.005-0.02 Hz. Note strong dispersion and periods of 60 seconds. Tag contents list station/channel, distance (deg), and backazimuth (deg).

Chapter 8

Conclusions and Recommendations

The total waveform data available from the GTDB exceed 2.5 Gigabytes. Each waveform has been reviewed by an experienced analyst to identify the phase arrivals. The database includes 800 events, most of which are located in the ME-NA region. Associated with these data are over 8,500 phase arrivals, timed and named by expert analysts. Over 4,400 of these phases are standard crustal phases (Pn, Pg, Sn, and Lg) observed at distances of less than 20 degrees.

We have developed efficient methods of retrieving and parsing waveform data from the pIDC and IRIS archives. We have also developed efficient methods of documenting and distributing finished products: the GTDB Web site and FTP sites have been popular among CTBT researchers. Our data have been loaded into the research databases at LLNL, Sandia National Labs, and the Air Force Technical Applications Center (AFTAC). Our work has facilitated CTBT research in the ME-NA region by providing research-ready data products in one consistent format. Evidence for this claim is the numerous research studies utilizing GTDB data published in 1996 (*e.g.*, Alexander and Yang; Baumgardt; Dowla *et al.*; Gupta and Zhang; Pulli; Sweeney). Recently released datasets will no doubt be the subject of more research in 1998, especially those studies focusing on propagation characteristics of regional phases.

For datasets with hypocenters taken from global bulletins, there is probable location error, especially for small, shallow events (Sweeney, 1996). Location error should be addressed before using these events for travel-time studies. We have sampled several earthquake series where abundant regional data are available for events close to one another. The SAUDI and the REB EQ datasets are good candidates for relative re-location because they include aftershock sequences recorded at several regional stations.

If there are any questions about GTDB data products, please contact the authors.

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Chapter 9

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